The Physics Teacher

# Meteors by radio: Getting started

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Citation: The Physics Teacher **37**, 123 (1999); doi: 10.1119/1.880168
View online: http://dx.doi.org/10.1119/1.880168
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Published by the American Association of Physics Teachers

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# Meteors by Radio: Getting Started

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The information given here will enable a student to do a science fair or other special project that will lead to some measure of success—not to disappointment. By sharing my own experience, I think any teacher or student interested in detecting meteors will be able to assemble a "meteor-by-radio" observatory with a minimum of grief. Further, such a project could become a relatively long-term hobby.

## A Little Theory

What causes meteor sounds in a radio? Imagine the meteor trail of ionized gas as a momentary reflecting surface. A distant radio transmitter's emission—preferably from beyond the horizon—briefly "sees" a reflecting surface. Suddenly, for a second or so, the signal strength at the receiver increases.

Now imagine a situation in which a listener can just barely hear a distant radio (or TV) station. Then, if a meteor is traveling at exactly right angles to the great circle line joining the receiver to the transmitter (see Fig. 1), the frequency of the reflected signal will be the same as the transmitted signal because the distance between the reflecting surface and the receiver is not changing noticeably. In other words, there is no Doppler shift, but simply a constant time delay (phase shift) between the directly received and the reflected signals. The listener might hear a kind of echo effect.

However, if the meteor is traveling in such a way that a velocity component of its trajectory exists along the line joining the receiver to the transmitter, then the wave reflected from the meteor tail is moving relative to the listener—there is a Doppler shift! If this relative velocity is constant, the Doppler shift will be constant, and the listener will hear a steady tone for the duration of the event. In other words, the beat frequency is constant. If the relative velocity is changing, the listener will hear something that can be described as a "ping," a sound similar to that given by a tuning fork.[1] In other words, the beat frequency is changing.

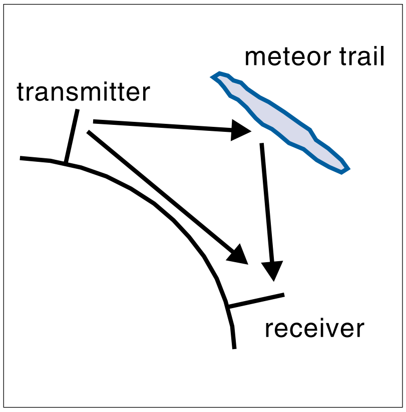


**Fig. 1. Idealized diagram of a meteor event detectable by radio.**

## Hearing the Meteors

Of the several techniques[2] available for "observing" meteors by radio, using an AM (Amplitude Modulated) radio to detect a TV video carrier is the way to go for the entry-level observer. The strategy is to have the radio tuned to some distant TV station's video carrier, even though the video carrier (which produces a slight buzzing sound, the 60-Hz vertical synchronization pulse) changes somewhat in intensity due to changes in the average level of the video signal. Once we hear that buzz, we expect the following: whenever some of that video carrier is reflected from a meteor's ionized trail moving toward or away from us, we will hear a ping. Since many TV stations are on 24 hours a day, it is possible to "observe" meteors at random times.

## Equipment Needed

First, there must be at least one unused TV channel within your area,[3] preferably in the low VHF range (channels 2 to 6)[4] because reflection efficiency falls off as channel frequency increases. Then, the radio must be capable of AM detection and tune accurately to the low VHF channels. The popular radio "scanner" is the most cost effective.[5]

You don't need a big antenna. I have a dipole[6] antenna hanging inside my bedroom. This is a viable solution



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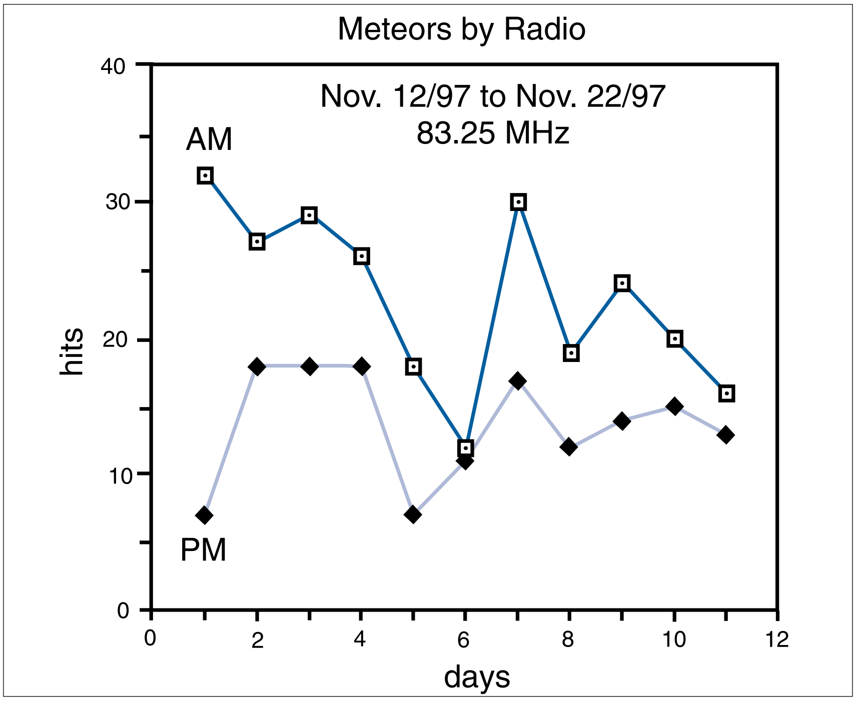


**Fig. 2. Plot of number of "hits" as a function of day and time of day. The number of hits does not take into account differences in kinds of hits. A few minutes one way or another should not introduce any major surprises.**

in a situation where the building is of nonmetallic construction.

What else will you need? My interest in meteors began when an acquaintance here in Halifax contacted me because he was trying to detect meteors by radio but was getting nowhere. It became apparent that his radio was being "overloaded" by several local FM stations (his residence is in full view of the FM transmitter antennas just a couple of miles away). The selectivity[7] of his radio was simply not good enough. He had tried some filters between antenna and radio, but the solution was a band-pass filter with a Q (quality factor)[8] of at least 300 tuned to the TV channel of interest (channel 6). Success was immediate. The background noise level in his receiver dropped and he could begin hearing those elusive pings.

Now I was hooked. I began to monitor meteors, learning the problems associated with getting started in the activity and becoming familiar with the kind of data that could be collected. Every once in a while there would be a day or more during which the background noise was higher than usual, thereby no doubt masking some meteor "hits." But even then, over a ten-minute period there would usually be at least one fairly definite hit.

## Data to Gather

A student might be interested in doing a survey experiment, making observations (preferably on a daily basis) at some relatively fixed time(s) of the day. In my case, I found the early morning (around 8 AM local time, 12:00 UTC) convenient and I listened for exactly 10 minutes. For comparison purposes I did the same thing around 5 PM local time (21:00 UTC). My data are plotted in Fig. 2.

Another student may prefer to concentrate on the way the pings vary in frequency. This is of interest because the student can calculate the velocity component of the meteor along the line joining his site to the meteor. The calculation is done by estimating the frequency or pitch of the ping and then applying the relationship:

$$\frac{\text{ping frequency}}{\text{video carrier frequency}} = \frac{\text{radial velocity component}}{\text{speed of light}}$$

For example, a nominal ping frequency of 500 Hz and a video carrier frequency of 83.25 MHz gives a nominal radial velocity component calculated from

$$\frac{500\text{Hz}}{83.25 \times 10^6 \text{ Hz}} \; 3 \times 10^8 \text{ m/s} =$$

1800 m/s = 6500 km/h.

The student could then produce a plot showing the distribution of the number of pings per unit time as a function of radial velocity component. There is an obvious challenge in estimating the ping frequency easily; perhaps a piano might be handy.[9]

Much additional information on meteors is available on the Web.[10]


## Acknowledgment

Many thanks to my colleague of many years, Robert Schultz, VE1IF, for helpful discussions and for providing a high-Q band-pass filter.


## References


1. Sometimes there will be relatively long "pings," perhaps several seconds; other times there might be tones that "flutter," perhaps due to the motion of aircraft producing constructive and destructive interference effects. The listener will hear a number of different sounds. After a week or so of daily listening, the short-lived pings are readily recognized.
2. For more information, try searching the Web under "meteors."
3. "Your area" is defined approximately as the circular horizon centered on your receiving site.
4. The video-carrier frequencies are 55.25, 61.25, 67.25, 77.25, 83.25 MHz for channels 2 to 6, respectively. In my situation, channel 6 is the most appropriate.
5. A deluxe scanner such as the ICOM R-7000 is expensive




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(over $1000). A perfectly suitable alternative is Radio Shack's PRO-60 (around $300).

6. Radio Shack's antenna #42-2385 or "rabbit ears" type #15-1827, along with a balun #15-1140 and adapter (from F to BNC type), is all that is needed.
7. Equivalent to the band-pass characteristics.
8. Construction details for a suitable filter can be found in any recent issue of *The Amateur Radio Handbook*. We used a modified surplus VHF "can" filter such as telephone companies have in their mobile radio installations. (The filter is in the form of a metal can long enough to contain a quarter-wave resonant line.) Students living where there are simply no usable "blank" TV channels could try a combination of high-Q band-pass and band-reject filters. Contact local amateur radio stores for suggestions on sources of filters.
9. The frequency or pitch of the ping could be obtained electronically with a frequency-to-voltage converter or by computer-controlled frequency-counting software. Although a ping is usually not just one well-defined frequency (because the velocity component of the meteor trail is not likely to be traveling at a constant radial velocity relative to the observer), most pings do exhibit some "dominant" or "average" frequency.
10. See, for instance, American Meteor Society (meisel@uno.cc.geneseo.edu; www.serve.com/meteors/faq1.html); also steyaert@vvs. innet.be for the Radio Meteor Observation bulletins, and 72632.1427@compuserve.com.

## Physics Olympics

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*This fourth Olympics column has two activities based on the concept of reflection. The first, an adaptation of the traditional Rutherford scattering activity, can also be used as a lab experiment. The second uses four mirrors to "hit" a target with a laser beam. This activity turns out to be more instructive than others we have used employing lenses and prisms.*

Karen Bouffard

Instead of shooting alpha particles to determine the nature of the nucleus, students use reflected laser light to determine the "nature" of a hidden object. Students work in teams of four or five.

**Time:** 30 minutes (two or three teams may work individually at the same time)

**Equipment (per team):**

- One laser pen or pointer
- One wooden object, about 2 cm high, of somewhat regular shape (see examples in Fig. 1)
- One meterstick or ruler
- Cardboard square large enough to completely conceal the object from even "glancing" views (see Fig. 2)
- Mylar film or bendable mirror tape
- 24- x 24-inch paper

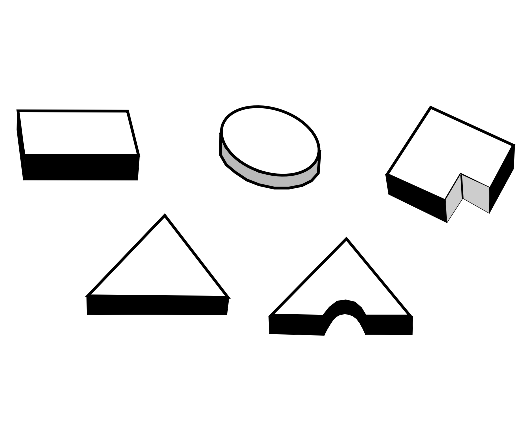

**Fig. 1. Sample shapes.**



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