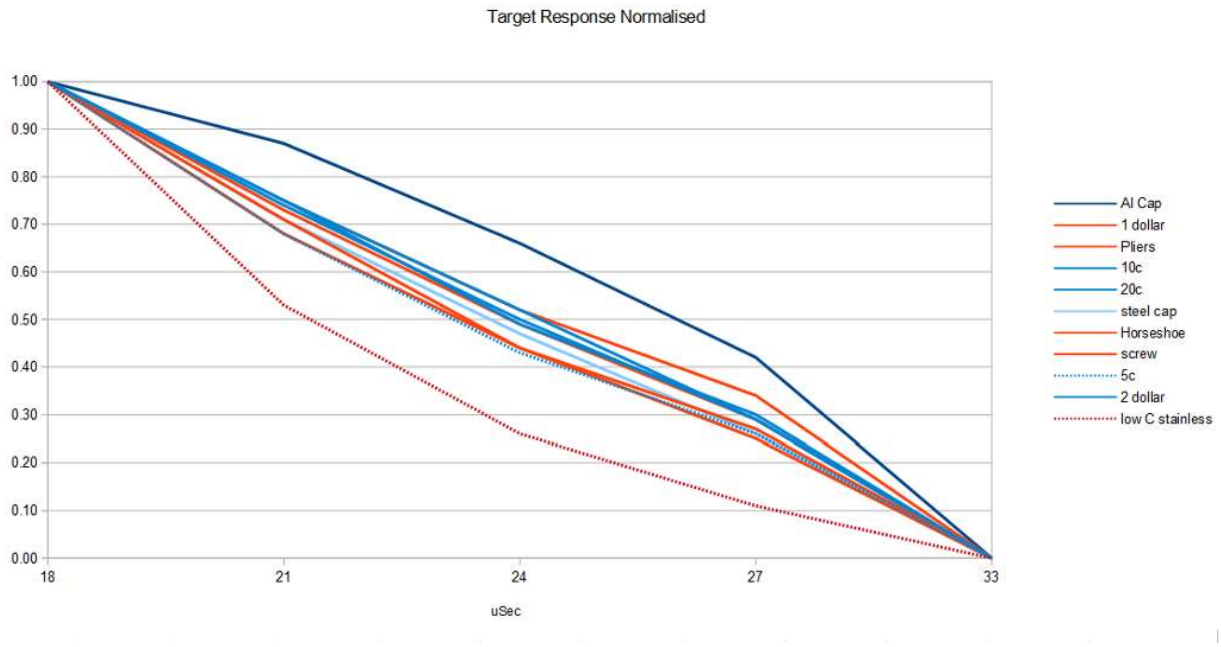
Wombat Discrimination

Discrimination on the Wombat PI detector, uses multiple samples at different 'delays' to guess the conductivity and Iron-content of a target.

Specifically, multiple analog samples are taken at between 15uSec and 40uSec (micro seconds)
This is the time where our target is reacting with our coil pulse.

Faster microprocessors, make it possible to focus on this narrow time-window.

See the chart below, it shows normalised target responses at 5 different points (sample delays); 18uSec, 21uSec, 24uSec, 27uSec, 33uSec.
The 'Target Response' is the change in signal strength when there is a target present.



'Normalised', means the we can see the Shape of the response. Comparing the target signal at the different delays (time points)
It is interesting to note that the 'Shape' is fairly consistent regardless of the Target distance.
That is; a particular target will have the same particular shape if it is 5 cm away or 30 cm away from the coil.

In the chart , IRON (Fe) targets are plotted in red and 'Purely conductive' (Non Fe) targets are in Blue.
Note, that the targets shown are physically different, in particular the Horseshoe and the Screw, these are completely different in size and shape, but have comparable curve-responses. The most Conductive target appears to be the Aluminium bottle cap (dark blue), and the least conductive is the Low-c (Low conductive) Stainless steel.

The most important observation is that IRON targets tend to have similar 'middle' responses.

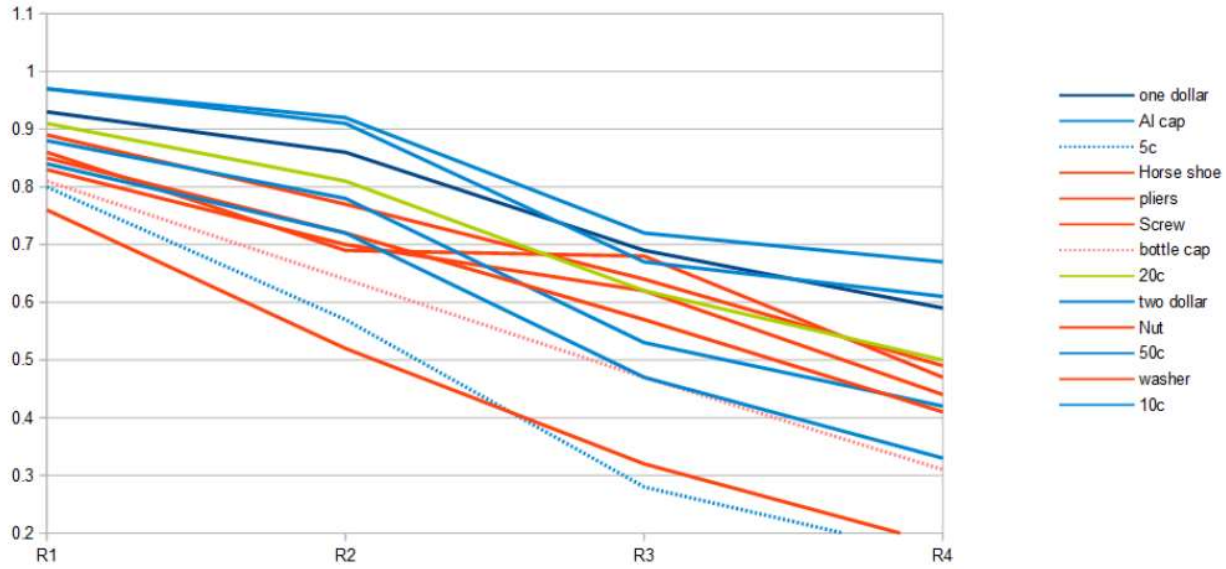
One way to describe this is : Large Iron targets appear 'less conductive than they actually are', and Small Iron targets appear 'More conductive than they actually are'.

This is because, apparently in the case of Iron, there are two factors affecting the shape of the response: The Iron content, and the eddy currents.

It's not easy to discriminate, but we can find general rules:

After measurements and observation of many different targets,
We can choose a set of comparisons to maximise the difference between target responses:

R1 (ratio 1) (21 uSec / 18 uSec)
R2 (24 uSec / 18 uSec)
R3 (33 uSec / 24 uSec)
R4 (33 uSec / 18 uSec)



The Chart above suggests that we can tell the difference between
3 types of target: Very conductive non-Iron targets, very low-conductive non-Iron targets, and 'everything-else' including Iron (Fe).

The more conductive (NonFe) targets such as 'one dollar' have a larger and more level response between 18uSec to 21uSec (R1) and 18uSec to 24uSec (R2).

The lower-conductive non-iron targets in general, have a bigger change between R2 and R3; a more 'peaky' response.

Algorithm

We can implement the following algorithm to classify targets into 3 groups

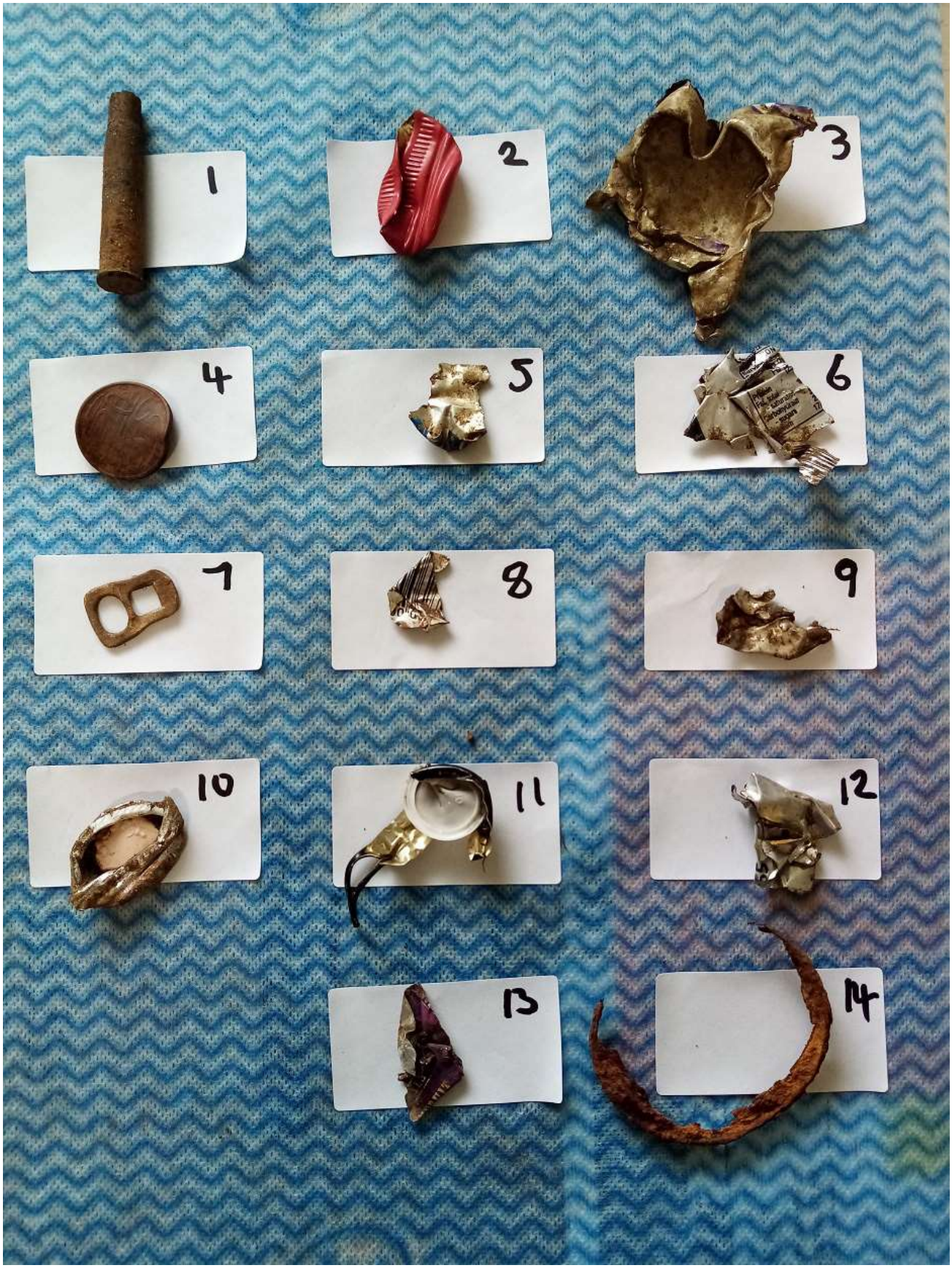
```
void IS_TARGET_A(double r2, double r3)
{
  if(r2 > 0.7)
  {
    TARGET_SENSE::targetID = OK_BIG;
  }
  else if ((r2 -r3)  > 0.2)
  {
    TARGET_SENSE::targetID = OK_SMALL;
  }
  else
  {
    TARGET_SENSE::targetID = Fe;
  }
}
```

We can use the target classification to set the Audio Tone:

High Tone:	Conductive non-iron target
Middle Tone :	Small, less conductive non-iron target.
Low:	Probably Iron but could be medium sized non-Iron.

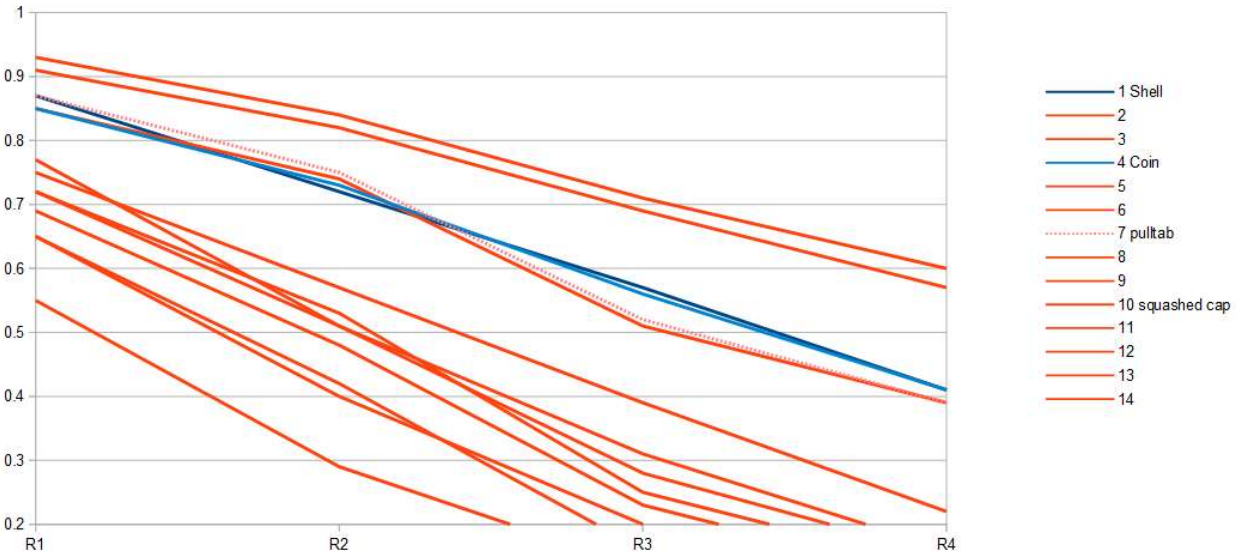
Field Testing in a Park

Here are the first 14 targets dug from a typical (modern) Park, the park is 60 years old which makes it fairly modern and devoid of older coins.
However, in general it contains plenty of iron and aluminium junk.
The process involved digging the first 14 definite: High-Tone and Middle-Tone targets only.


1
2
3
4
5
6
7
8
9
10
11
12
13
14

All targets were purely conductive with the exception of number '14' the piece of tin-can that technically contains Fe

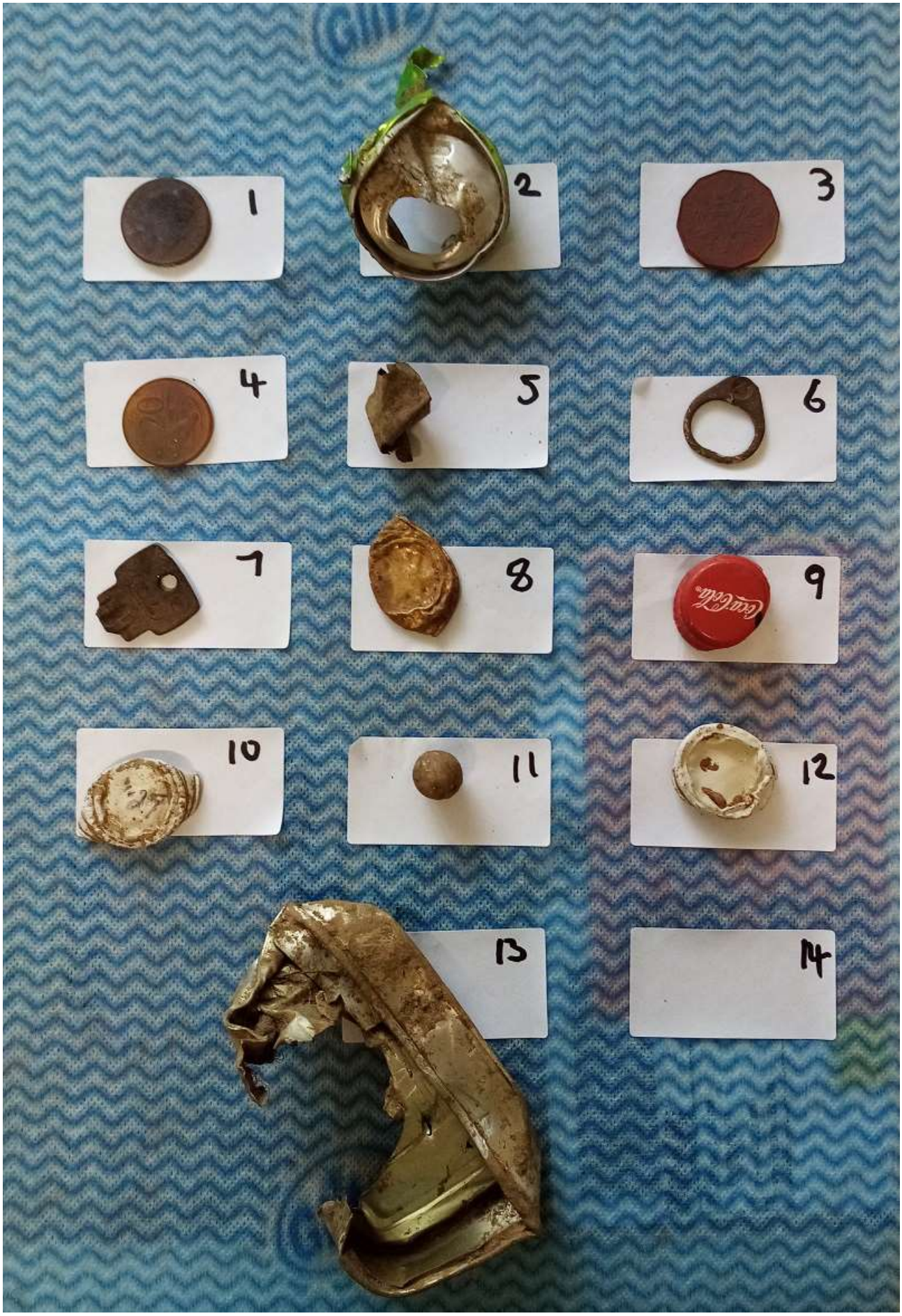
If we consider only 2 targets above worth-while '1' The bullet shell and '4' the bent coin. and colour them Blue, all true junk targets are coloured Red.
This time, 'Red' means 'Trash' (because there are no Iron targets)



From this, it's interesting to note that our worthy targets are fairly conductive and if we ignored all targets below R2 = 0.7, we would eliminate 60% of our junk.

The field test is repeated, but this time, we only dig targets that are very-conductive, high tone.

This time, it took longer to find worthwhile targets, and the worthwhile-target to junk ratio was improved:


1
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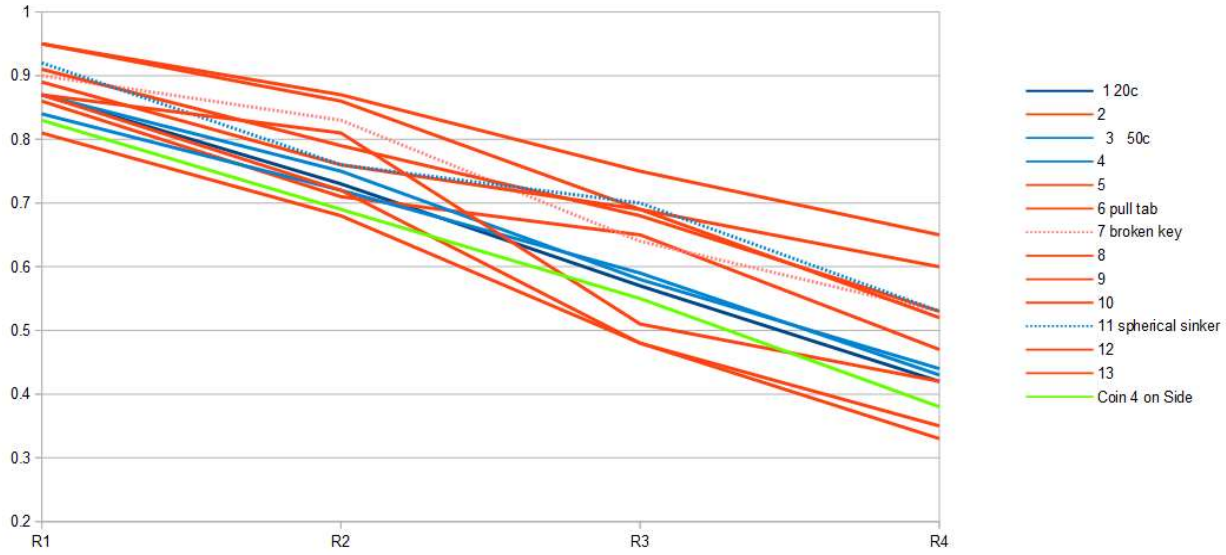
14

The responses of this new target set are plotted below,
as expected, they are all high conductivity non-Iron.
The Coins are plotted in Blue and Green, all other targets are plotted in Red



Thoughts and Conclusions

Further discrimination will be possible using finer analysis of the response shape.
For example the Coins have a consistent slope. Where as more physically uneven targets appear to have more uneven responses.
Note also The Green plot above is coin-4 on its' edge. The plot is similar regardless of orientation.

Coil used
Monocoil, 20cm Diameter, 428 uH, 2 ohm

END.