Bouncing Betas Bruce!

or: Measuring Beta Backscatter from Elements of Differing Atomic Number

by George Dowell

Material list:

1) A beta Source- Sr-90 used here (note 1), Tl-204 works well too. Cs-137 and other mixed sources may be used for their beta component in this experiment. If a mixed source such as Cs-137 (beta+gamma) is used, make sure to include extra shielding, such as 1/4" Pb (lead).

2) A coin, a US Quarter or $1 Euro.

3) Beta Probe. Pancake probe used here.

4) Counter/Scaler to take accurate measurements over a time period. Ours is the SPECTECH ST-350.

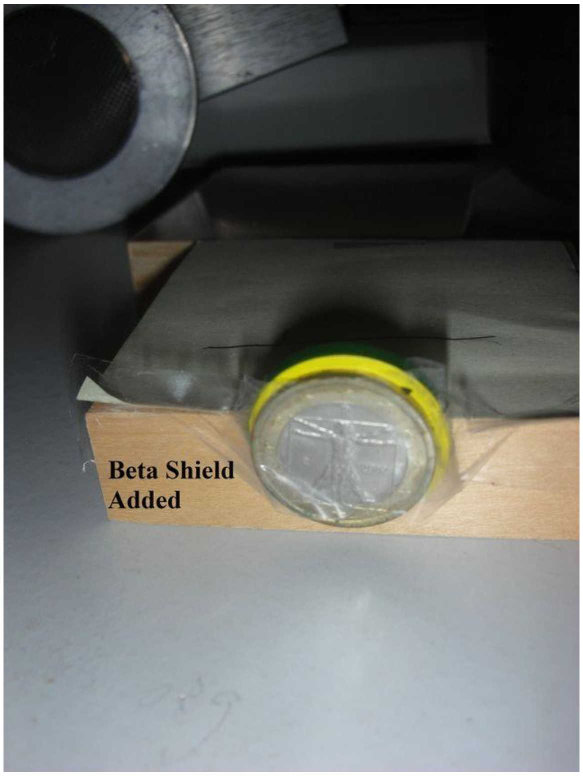
5) Reflector media. We have pure samples of Al, Fe, Co, Ni, Cu, Ag, Sn, Pb, plus try plastic, glass, paper and wood. You can use whatever you have around. All targets should have the same dimensions. Ours are 1" X 1 1/4". Thickness does not matter much for these tests.

NOTE: Where available, high resolution picture links follow photos.

Lab manual:

- FIG 1

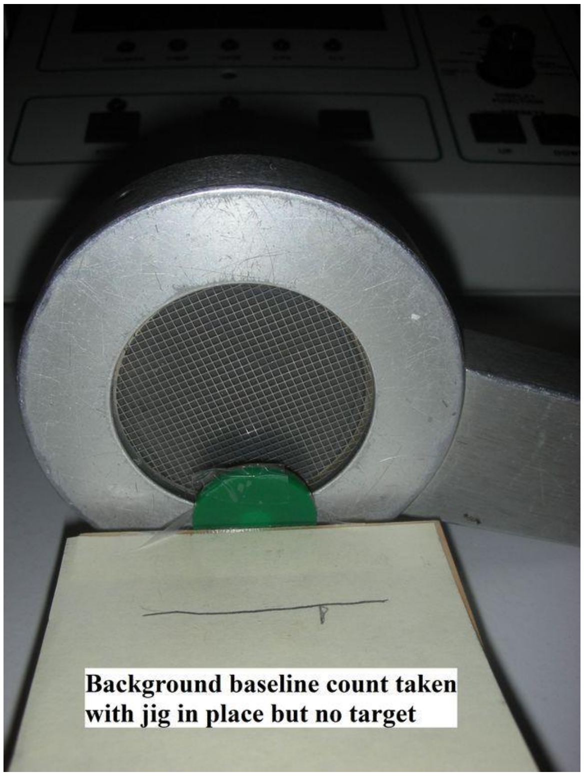
A coin shield is taped behind the beta source so that the radiation only goes away from the probe:



Then the source is taped to the end of a wooden block, this becomes the jig which holds everything stable while we change reflectors.

The test jig is positioned a short distance in front of the beta probe (pancake probe, thin end window, or thin sidewall GM) in such a way that none of the radiation reaches the probe directly. Once the jig is assembled, take a baseline background count with no reflector inserted. This count will be subtracted from all further counts, to yield a net contribution of only the reflected/backscattered betas.

- **FIG 2**



http://www.qsl.net/k/k0ff//Beta%20Backscatter/Jig%20Background%20Count.jpg

Set the scaler to run for 60 seconds, totaling the results when finished. A longer run time will be statistically more significant.

Start by taking a baseline background reading of the jig and source but no target. There is always a little reflection from the jig itself, and even your own body, so take an accurate count and subtract this number from the individual reflector target counts to yield a net CPM.

Gross CPM - Background CPM = Net CPM due to target backscatter.

expressed as: G^CPM - B^CPM = N^CPM

Next, one at a time, different reflector materials are placed in the <u>same carefully measured position in</u> front of the beta source. Space it away about an inch. Notice the space mark on the jig base.

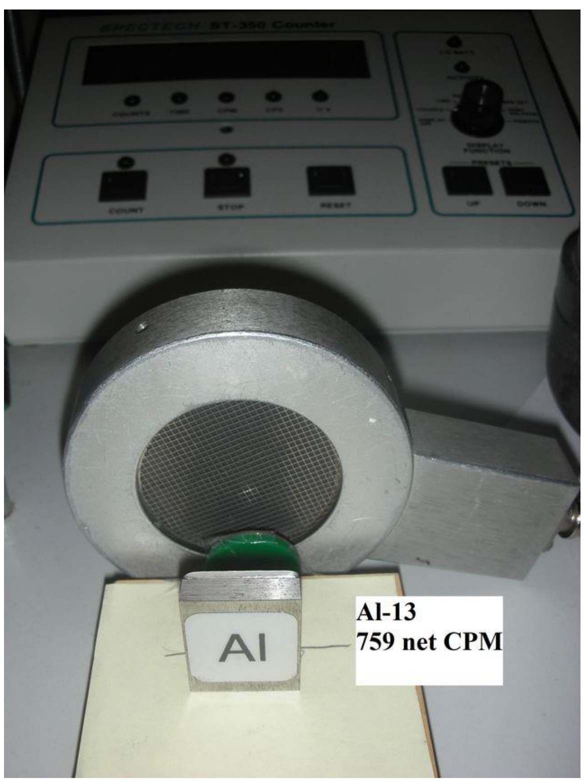
What we are looking for is the effect of different atomic number (Z) materials on a beta stream from the source, only those

betas that are scattered 180 degrees or close to it are detected.

<u>Our test results:</u>

- **FIG 3**

13 Al- 759 net CPM



http://www.qsl.net/k/k0ff//Beta%20Backscatter/Aluminum%20Al.jpg

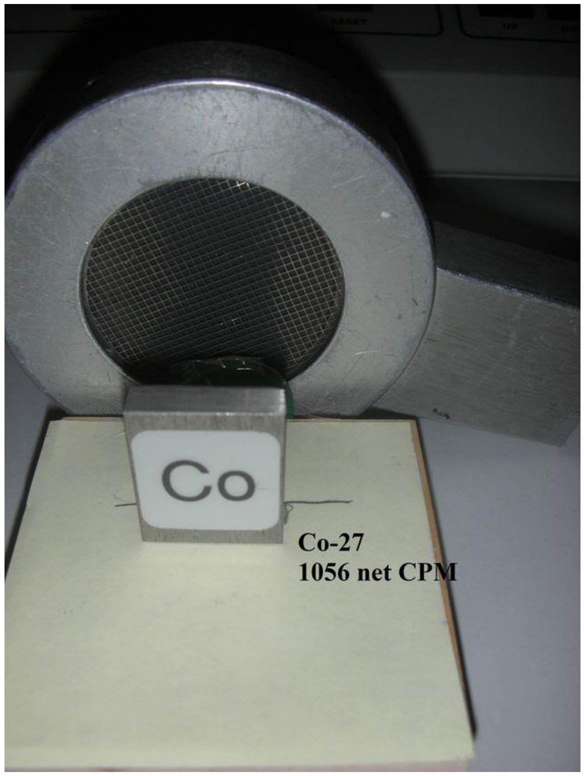
- **FIG 4**

26 Fe-1038 net CPM

http://www.qsl.net/k/k0ff//Beta%20Backscatter/Iron%20Fe.jpg

- **FIG 5**

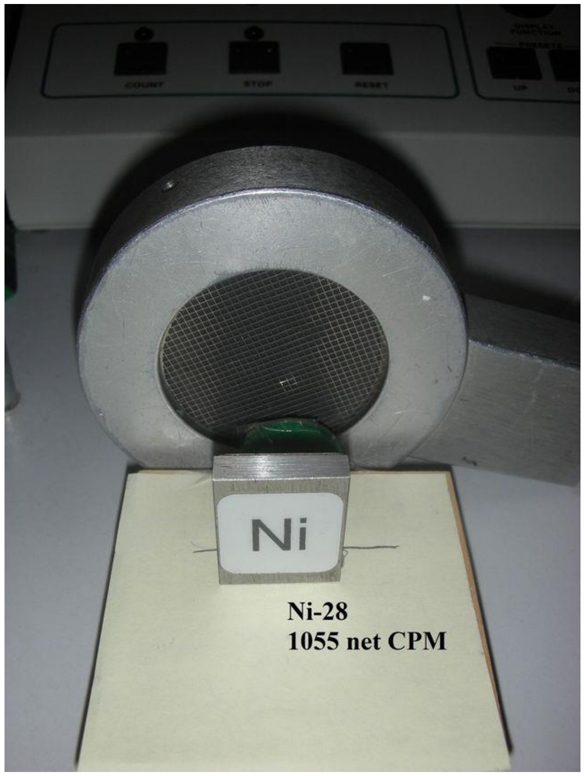
27 Co- 1056 net CPM



http://www.qsl.net/k/k0ff//Beta%20Backscatter/Cobalt%20Co.jpg

- **FIG 6**

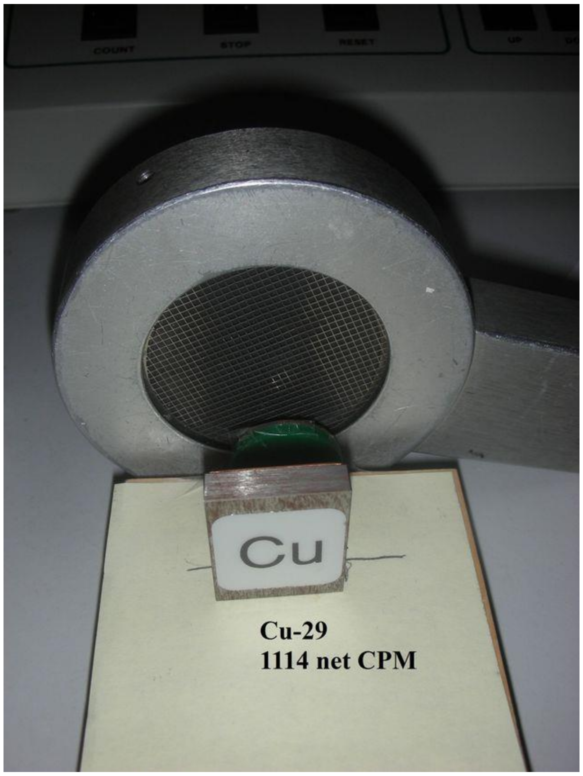
28 Ni- 1055 net CPM



http://www.qsl.net/k/k0ff//Beta%20Backscatter/Nickel%20Ni.jpg

- **FIG 7**

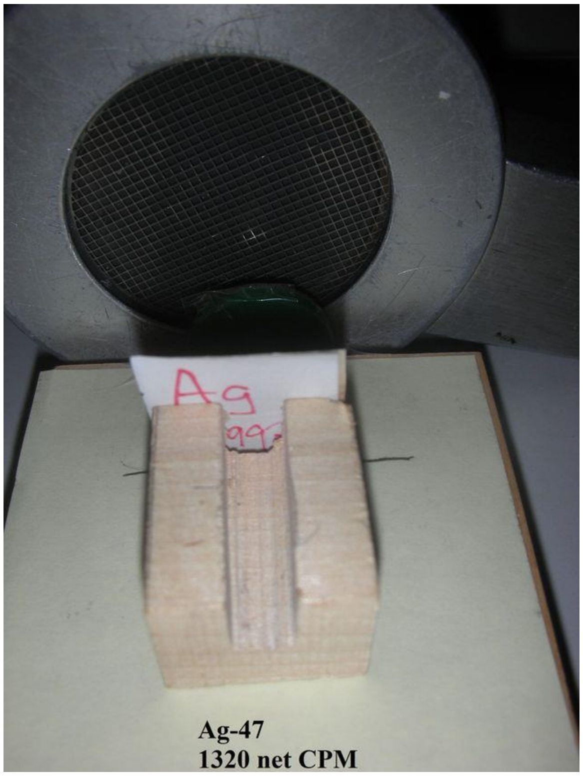
29 Cu- 1114 net CPM



http://www.qsl.net/k/k0ff//Beta%20Backscatter/Copper%20Cu.jpg

- **FIG 8**

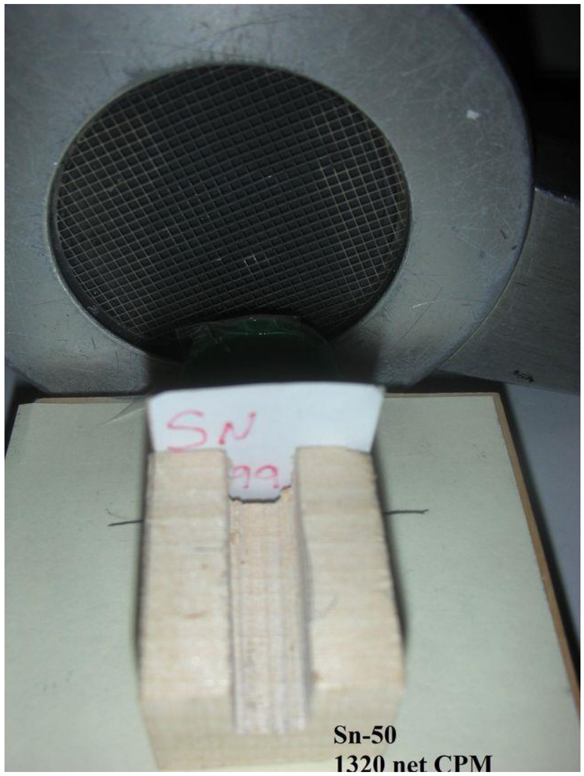
47 Ag- 1320 net CPM



http://www.qsl.net/k/k0ff//Beta%20Backscatter/Silver%20Ag.jpg

- **FIG 9**

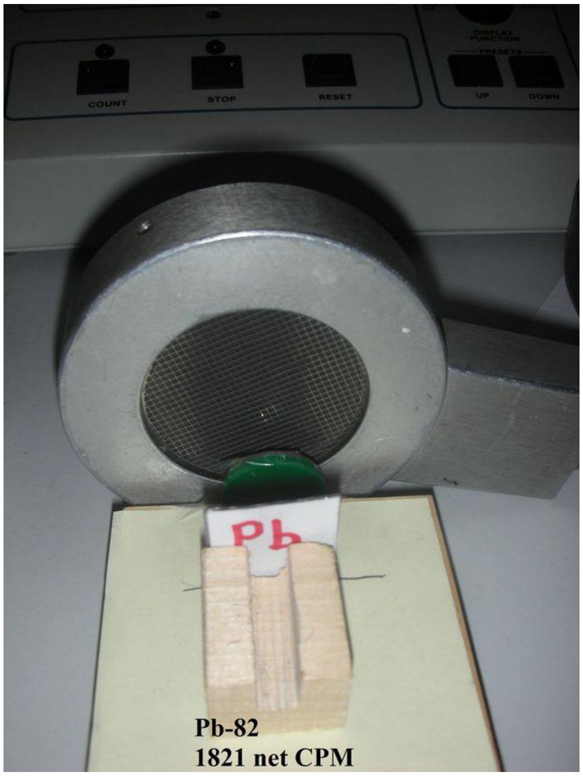
50 Sn- 1320 net CPM



http://www.qsl.net/k/k0ff//Beta%20Backscatter/Tin%20Sn.jpg

- **FIG 10**

82 Pb- 1821 net CPM



http://www.qsl.net/k/k0ff//Beta%20Backscatter/Lead%20Pb.jpg

Conclusions:

Betas will bounce off (backscatter) more as the Z of the reflector is increased. Elements that are very close in Z number

show little difference form one another, due to the randomness of the radioactive decay process and measuring uncertainties.

Elements far apart in Z number have markedly different reflective properties to the beta particles.

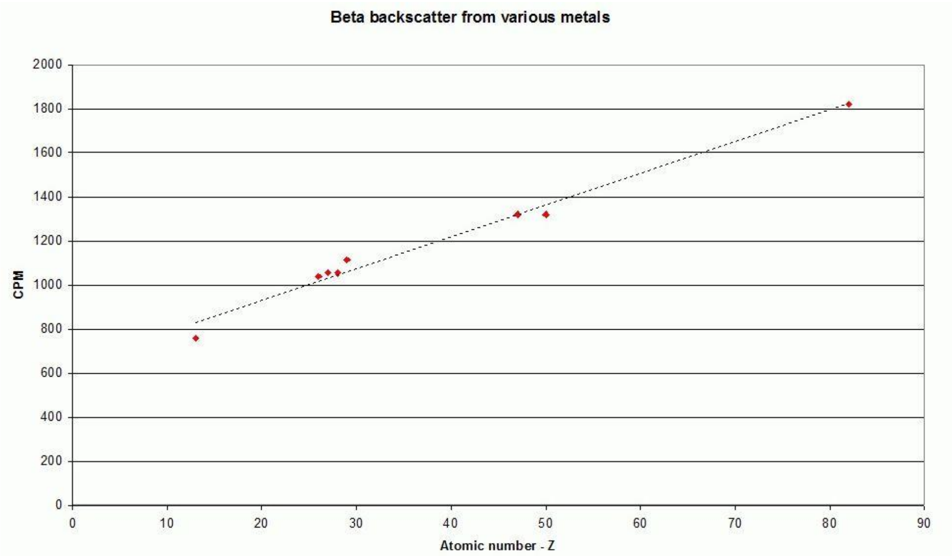


Chart of Data

The correlation coefficient (Pearson's r) = 0.99

- **FIG 11**

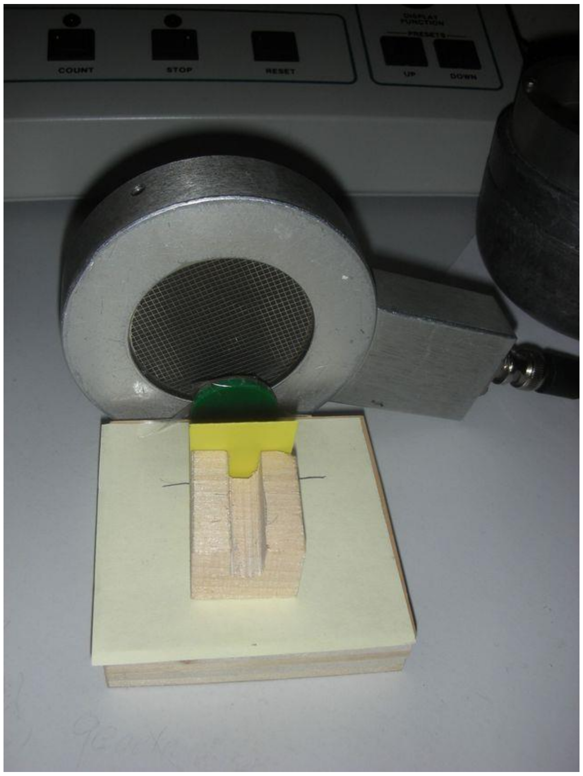
Note: Above chart custom prepared for this paper by Dr R J Prettyman and used with permission.

Note, a timed run was performed with Pb in the jig and a beta shield consisting of a 1.8 mm aluminum sheet covering the probe. This is done to verify it is betas we are seeing reflected and not Bremsstrahlung or PIXE generated characteristic X-Rays. These do of course exist with our setup but their contribution is minuscule with this detector, and totally swamped put by the betas.

Suggestions for further study:

Once you jig is set up and tested, try using other household materials as a target. Plastic, wood, glass are just a few.

- **FIG 12**



***(note 1): Gamma rays tend to be emitted in discreet energies, as do alphas. Betas on the other hand are emitted in a BAND of energies, from zero, to the MAX for that particular isotope (source). Sr-90 has a 100% yield of a beta of 546 keV MAX, 195.8 Average. Even though backscattered betas do lose some energy in the scattering process, the probe used here is very sensitive to betas, even of relatively low energies. when betas are bent via a magnetic filed, they do not lose energy, but the degree of bending has a direct relationship to the energy of each beta. Refer to article below "Bending Betas" for projects and details.**

Associated articles in this series by George Dowell:

PIXE- Element identification using Particle induced X-Ray Emission.

Measuring Beta Efficiency of a Pancake Probe - Using beta sources to test beta efficiency of probes.

Bending Betas- Bending betas using magnets. demonstrates the principles of Magnetic Beta Spectroscopy.

Nuclear Radiation Lab Experiments With Absorbers- Using calibrated absorbers to determine beta energy, alpha, beta and gamma penetration.

Have fun

George Dowell