Bending Beta Particles with Magnets

by George Dowell

There are many different types of atomic and nuclear radiation.

"Atomic" refers to the atom as a whole, but the commonly accepted definition of atomic reactions are those that originate in the electron shell area of the atom. "Nuclear" on the other hand is specific to the nucleus of an atom.

Some radiation consists of particles of matter, betas and alphas are the two main ones. Another kind of radiation is pure energy, in the form of photons. If those photon originate from the nucleus of an atom, we call it a Gamma Ray.

If the photon happens to originate from the electron shell area of an atom, we call it an X-Ray. Gammas and X-Rays are identical in every way except their origin.

In this lab demonstration we are concerning ourselves with beta particles. These are nearly massless particles, identical to an electron in every way, but they come from a nucleus, therefore they are a nuclear particle. Negatively charged beta particles are identical to an ordinary electron in every way, and are called negatrons. Positively charges beta particles which we call positrons are considered to be anti-matter, while negatrons are ordinary mater. As with all anti-matter particles, a positron will, only under the right conditions, annihilate itself and be replaced with a pure energy photon. During annihilation, a positron combines with a negatron, and they both disappear, replaced with a pair of 511 keV photons, which are 180 degrees opposed (matter converts to energy)

NOTE: Under a different set of circumstances not discussed here, energy in the form of a photon of more than 1022 keV (twice 511), can actually disappear in favor of an electron and a positron . We call this Pair-Production and is essentially energy converting into matter.

Beta particles are matter, therefore they are bound by certain rules. The main rule all matter obeys is that it cannot travel faster than light in a vacuum. This is the universal speed limit for matter. Electrons can travel pretty fast though, but instead of speed, we describe their kinetic energy condition in terms of electron-Volts. Typical betas from our sources will have kinetic energy in the thousands of electron-Volts, abbreviated:

keV. The higher the keV number, the more energetic is the particle. If the beta particle were at rest, we call it "thermalized" in which case it still holds 511 keV worth of energy. This number and twice this number are very important in the study of nuclear reactions. You've already read in the last paragraph where two beta particles can annihilate under only the right conditions. Those conditions are simply that each has lost all its excess kinetic energy and are at the rest mass = 511 keV (mass-energy equivalence). While gamma rays and alpha particles are generated at specific, discreet energy levels, betas come out in a range of energies from zero to a given maximum value for that particular isotope. Therefore we list beta energies in our articles using both their maximum and average values.

Fig 1 Materials List

The detector is an alpha-beta-gamma sensitive pancake GM type, hooked to a SPECTECH scaler-ratemeter Model ST-350. This instrument provides the high voltage needed to run the detector and also totalizes the counts produced by the detector, over a timed test period of 1 minute. Results are expressed in CPM (Counts Per Minute). Some of the beta and mixed beta-gamma sources we are to test are also shown.

The analysis magnet is a General Tools 16 ounce horseshoe "Power Magnet". N and S poles are identified by using a compass. REMEMBER THAT A COMPASS'S MARKED NORTH POLE POINTS TO THE MAGNETS SOUTH POLE!!

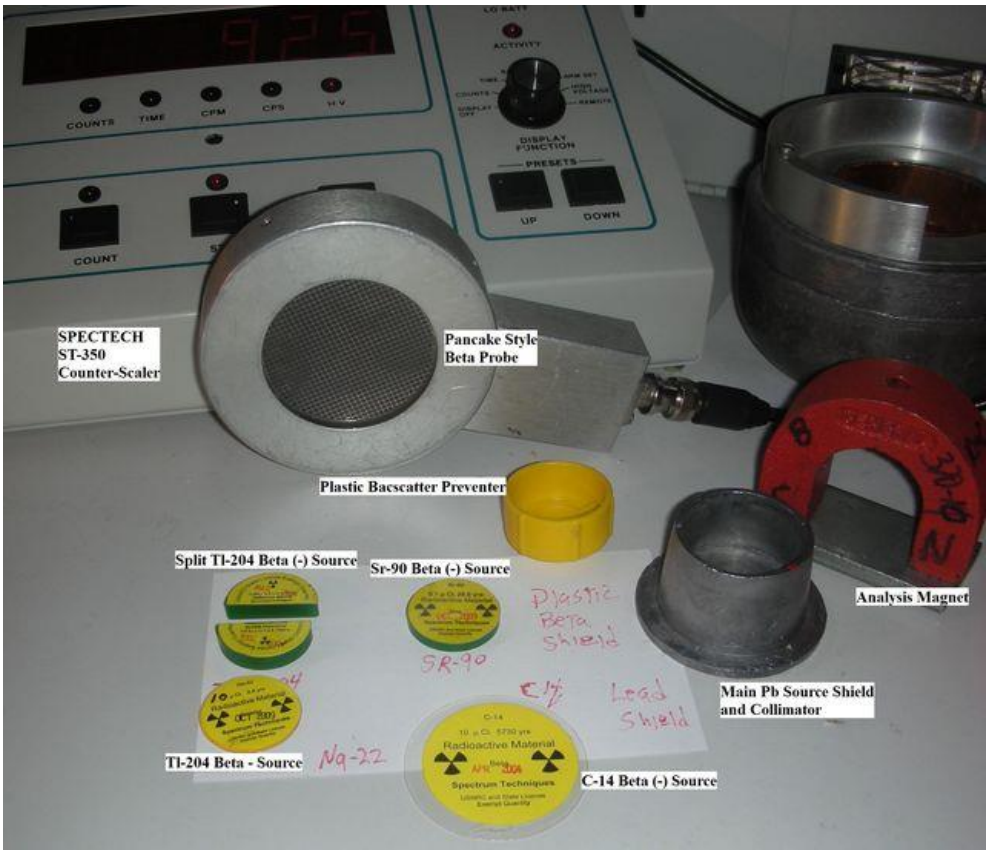
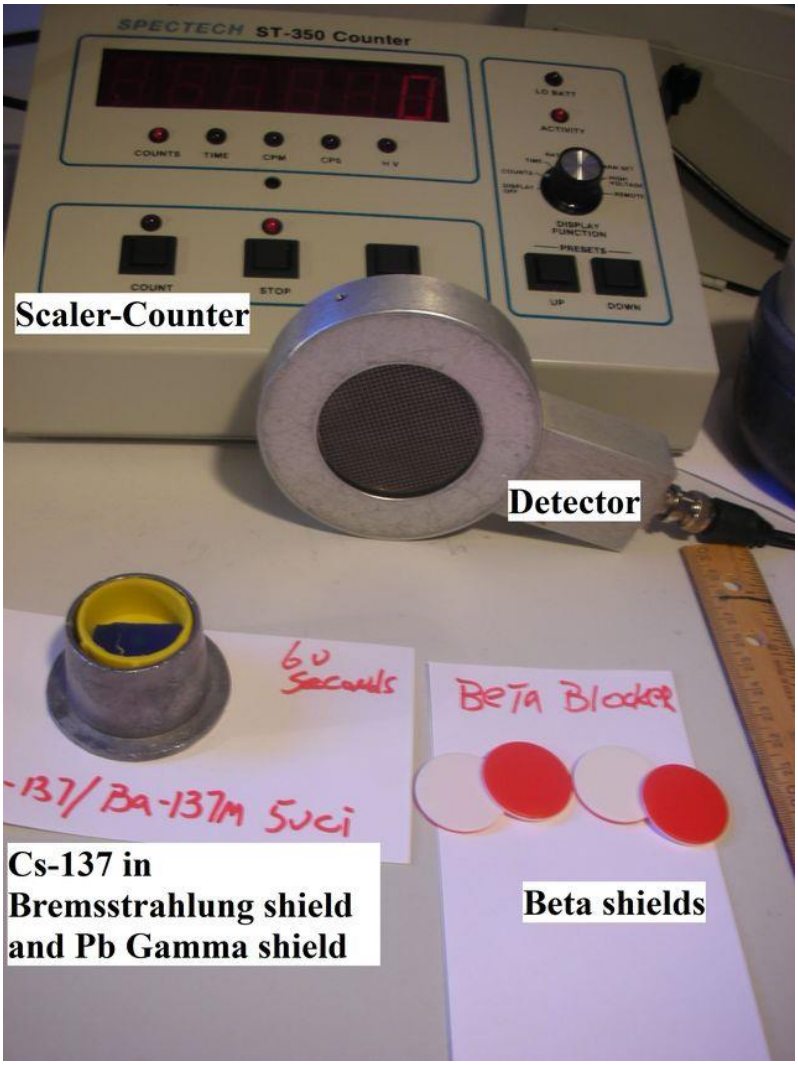


Fig 2: Source holder jig setup. Since we are separating the betas from any other particles or rays that may be coming from the source, we can use mixed- sources, that is one that has multiple types of radiation present. The Cs-137 source is an excellent school lab source, as it has both beta particles and Gamma rays



BEFORE EACH TEST, THE ISOTOPE IS PLACED IN THE JIG BUT WITHOUT THE MAGNET. A BASELINE BACKGROUND COUNT IS TAKEN TO DOCUMENT THE BETA SCATTERING ETC.> WITHOUT THE MAGNET PRESENT<.

BACKGROUND = BG ON THE NOTES.

N-S indicates North on left, South on right polarity.

S-N indicates South on left, North on right polarity

Cs-137 5 uCi Negative Betas (Negatrons)

94.6% 511 keV Max, 156.7 keV Average

Fig 3:

Cs-137 with magnet in N-S which is Reverse Polarity for negatrons. Few betas are deflected into the detector. Background (no magnet)= 850 CPM. Reverse Polarity = 160 CPM. Counts are LESS than BG because stray betas are directed AWAY from the detector.

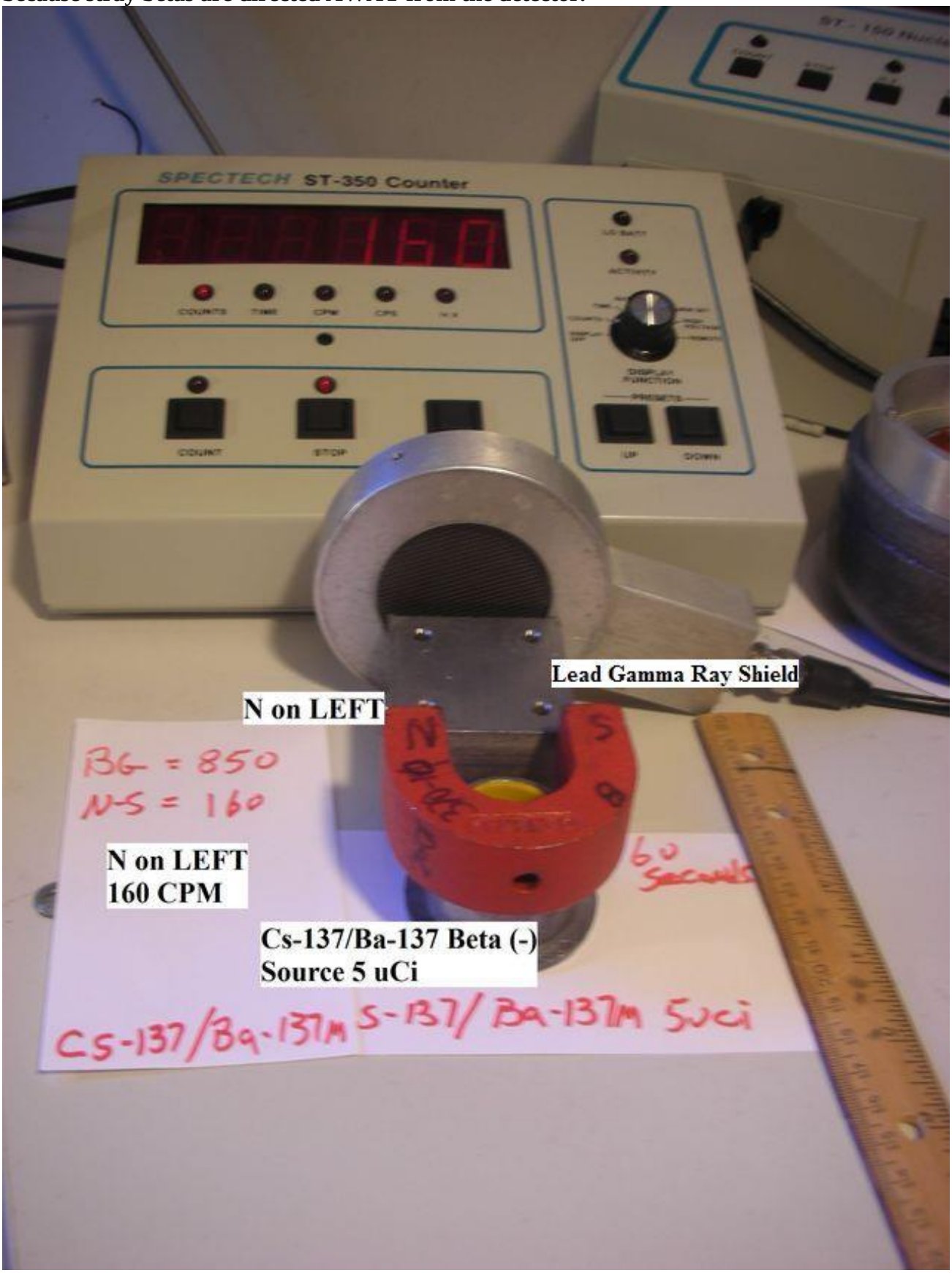
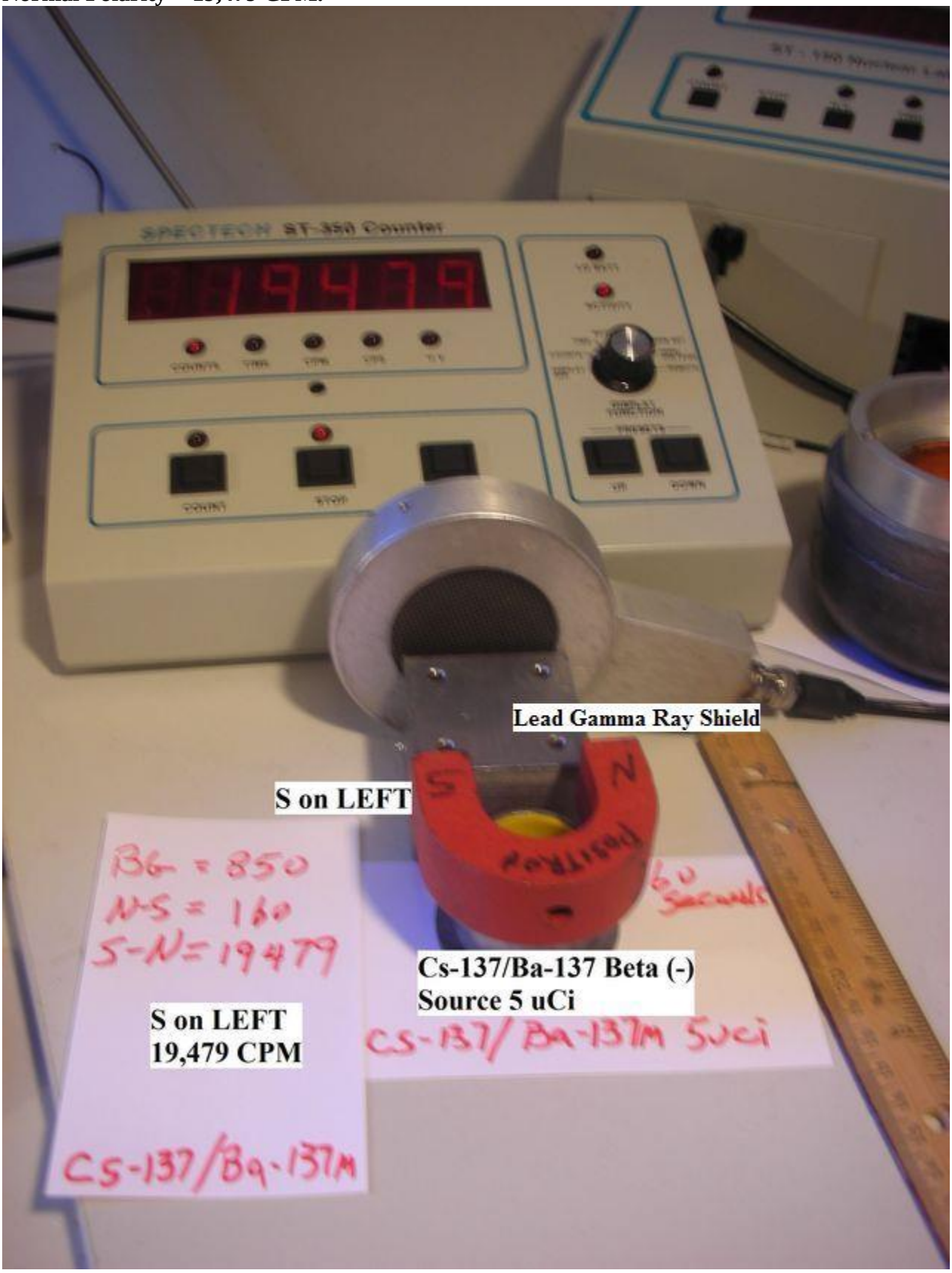


Fig 4:

Cs-137 with magnet in Normal Polarity (for negatrons). Many betas are deflected into the detector.

Background (no source)= 850 CPM.

Normal Polarity = 19,479 CPM.



SR-90/Y-90 Negative Betas (Negatrons)

100% 546 keV Max, 195.8 Average from Sr-90

99.9% 2283 keV Max, 934.8 Average from Y-90 daughter

Fig 5:

Sr-90/Y-90 with magnet in N-S which is Reverse Polarity for negatrons. Few betas are deflected into the detector.

Background (no magnet)= 970CPM.

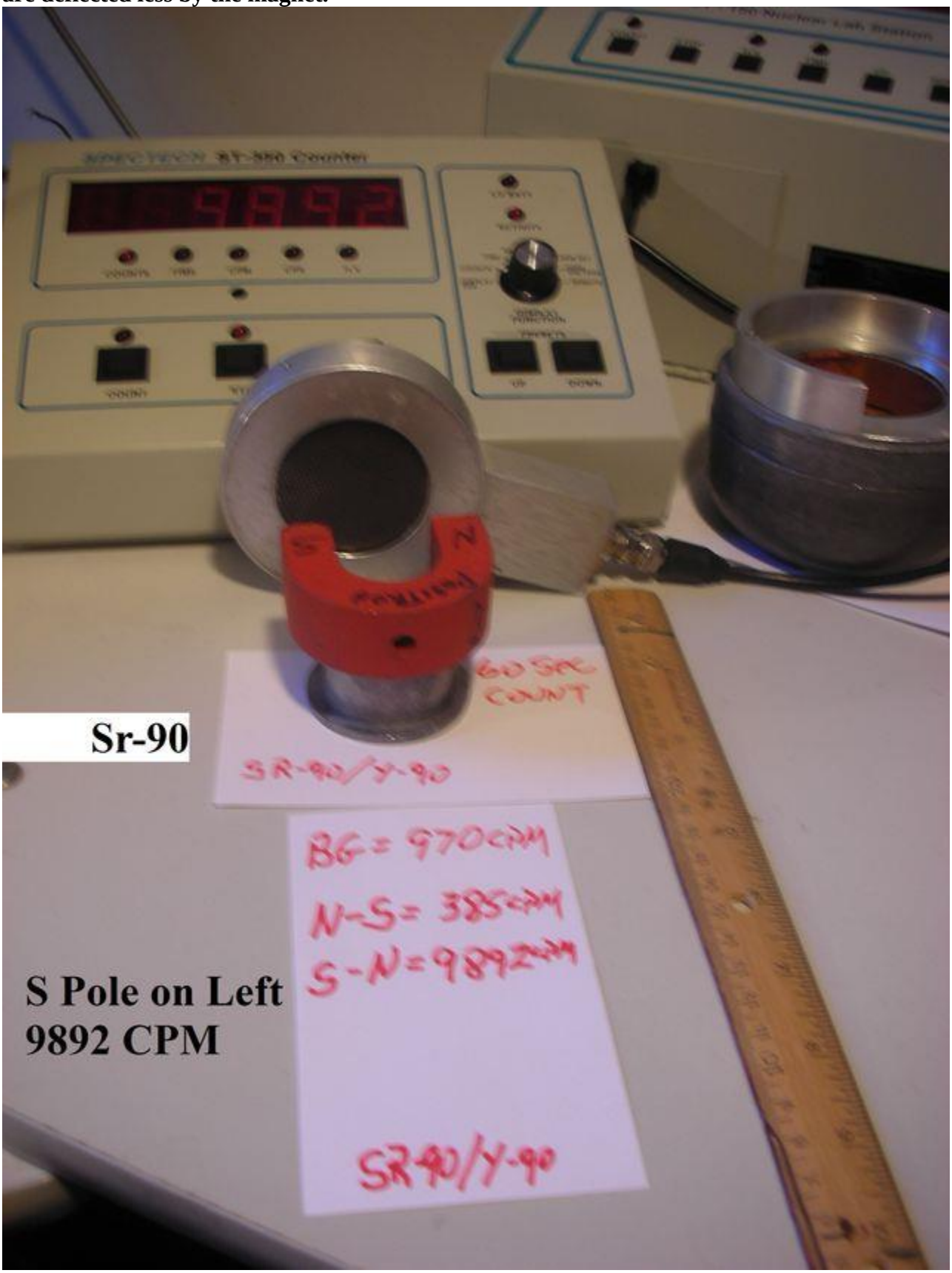
Reverse Polarity = 385 CPM. Counts are LESS than BG because stray betas are directed AWAY from the detector.

Fig 6:

Sr-90/Y-90 with magnet in Normal Polarity (for negatrons). Many betas are deflected into the detector.

Background (no source)= 970 CPM.

Normal Polarity = 9,892 CPM. Sr-90's betas are much stronger than those from Cs-137, therefore they are deflected less by the magnet.



Na-22 Positive Betas (Positrons)

89.8% 545.5 kev Max, 215.5 Average Positrons

Fig 7:

Na-22 with magnet in N-S which is NORMAL Polarity for POSITRONS. Many positive betas are deflected into the detector.

Background (no magnet)= 8918 CPM.

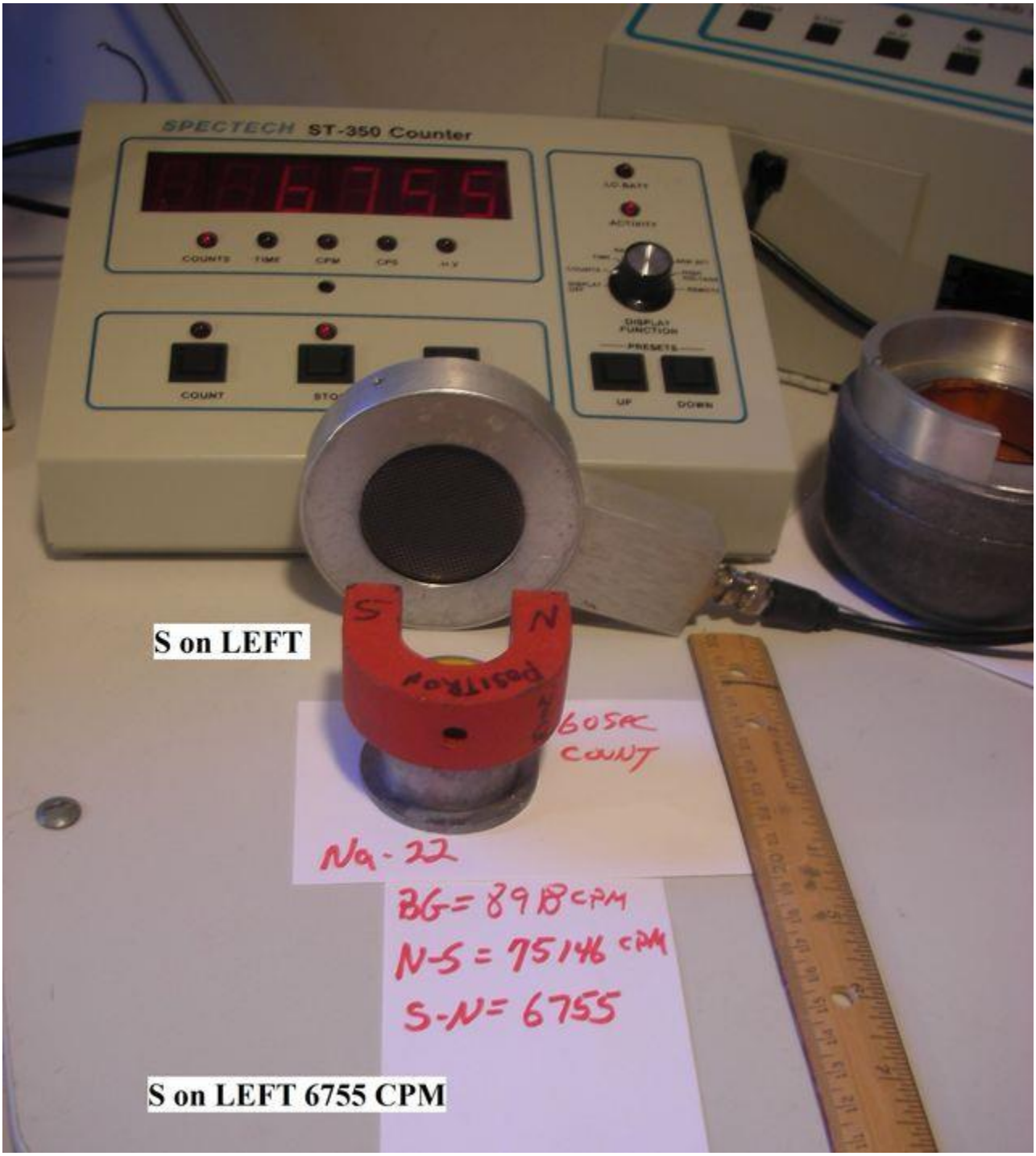
Normal Polarity= 75,146 CPM

Fig 8:

Na-22 with magnet in S-N which is REVERSE Polarity for POSITRONS. Few betas are deflected into the detector.

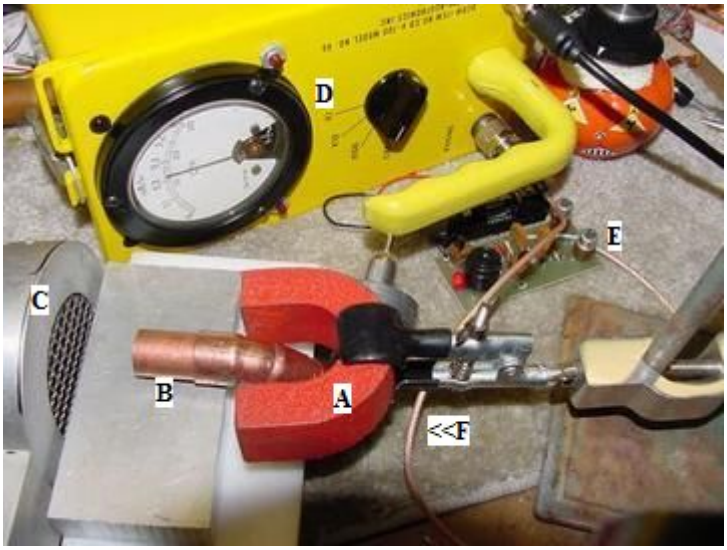
Background (no magnet)= 8918 CPM.

Reverse Polarity = 6755 CPM. Counts are LESS than BG because stray betas are directed AWAY from the detector.



Ideas for further experiments:

Here is the New London Bendatron Project. In this apparatus we confine the beta stream inside a copper drift tube (B).



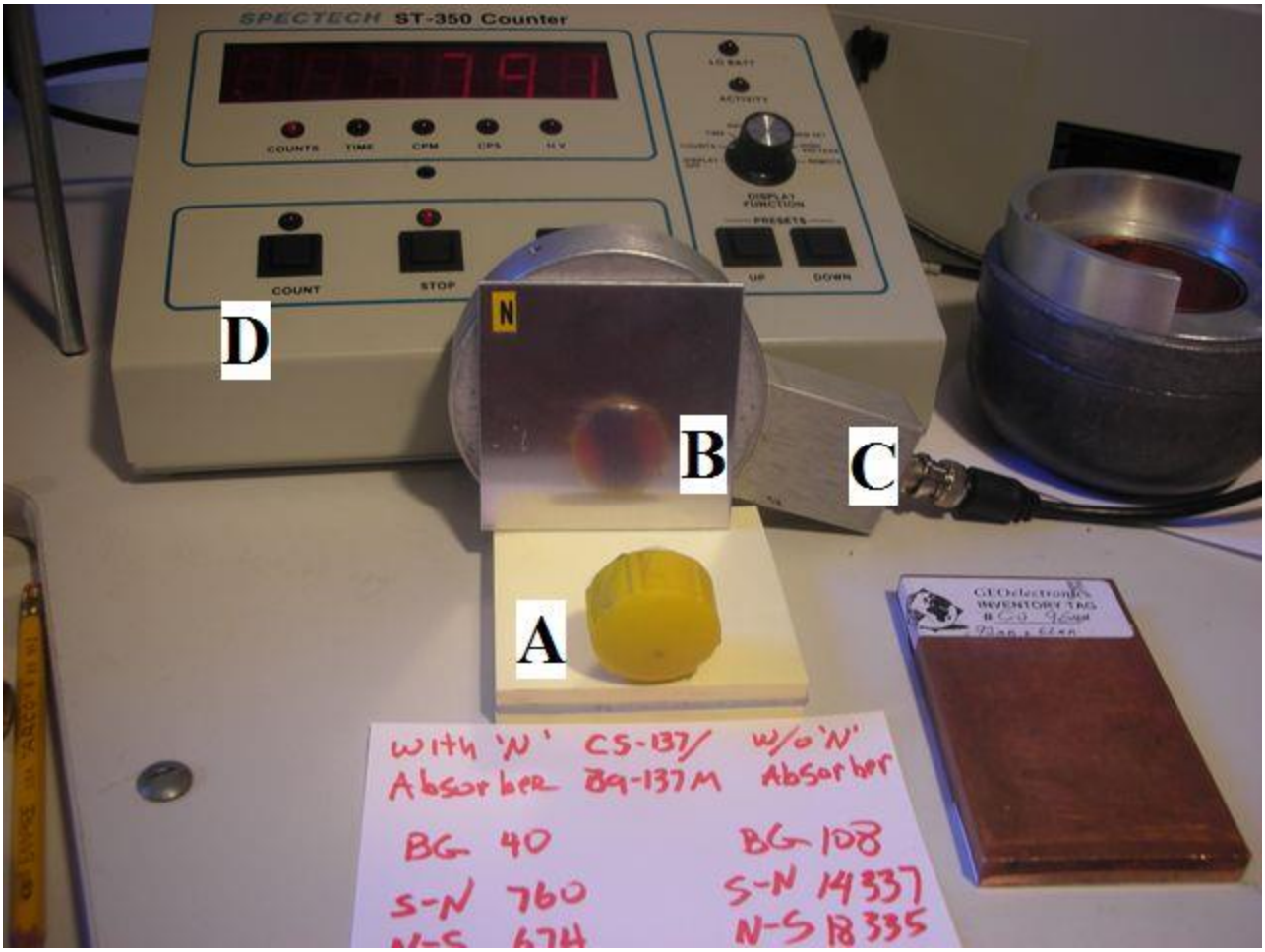
Cs-137 (A) beta-gamma source is shined directly onto the detector (C).

Beta blocked detector using the "N" absorber (B) from a SPECTECH CALIBRATED ABSORBER SET RAS-20

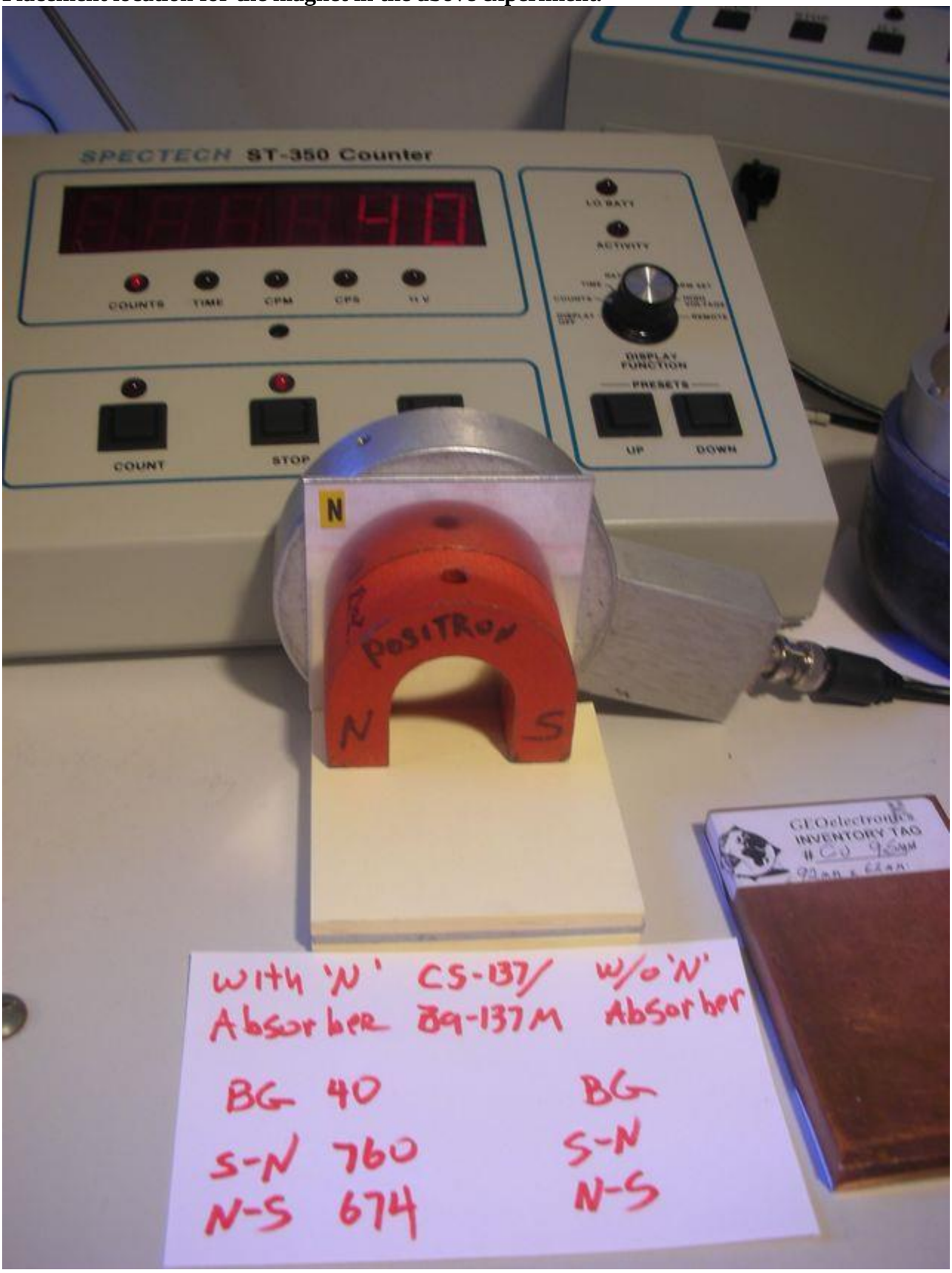
The magnet is placed in a vertical position between the source and detector, with and without the "N" absorber. (see following picture)

Changing the magnets polarity both with and without the absorber in places gives the readings shown. Why?

REMEMBER Cs-137 has both betas and gammas.


SPECTECH ST-350 Counter
COUNTS
TIME
CPM
CPS
COUNT
STOP
UP
DOWN
N
D
B
C
A
With 'N' Absorber
Cs-137/ Bg-137M
W/o 'N' Absorber
BG 40
S-N 760
BG 108
S-N 14337
N-S 18335

Placement location for the magnet in the above experiment.



Below is an experiment using TWO DETECTORS (D), (E). One (D) responds to the gamma only from the Cs-137 since gammas

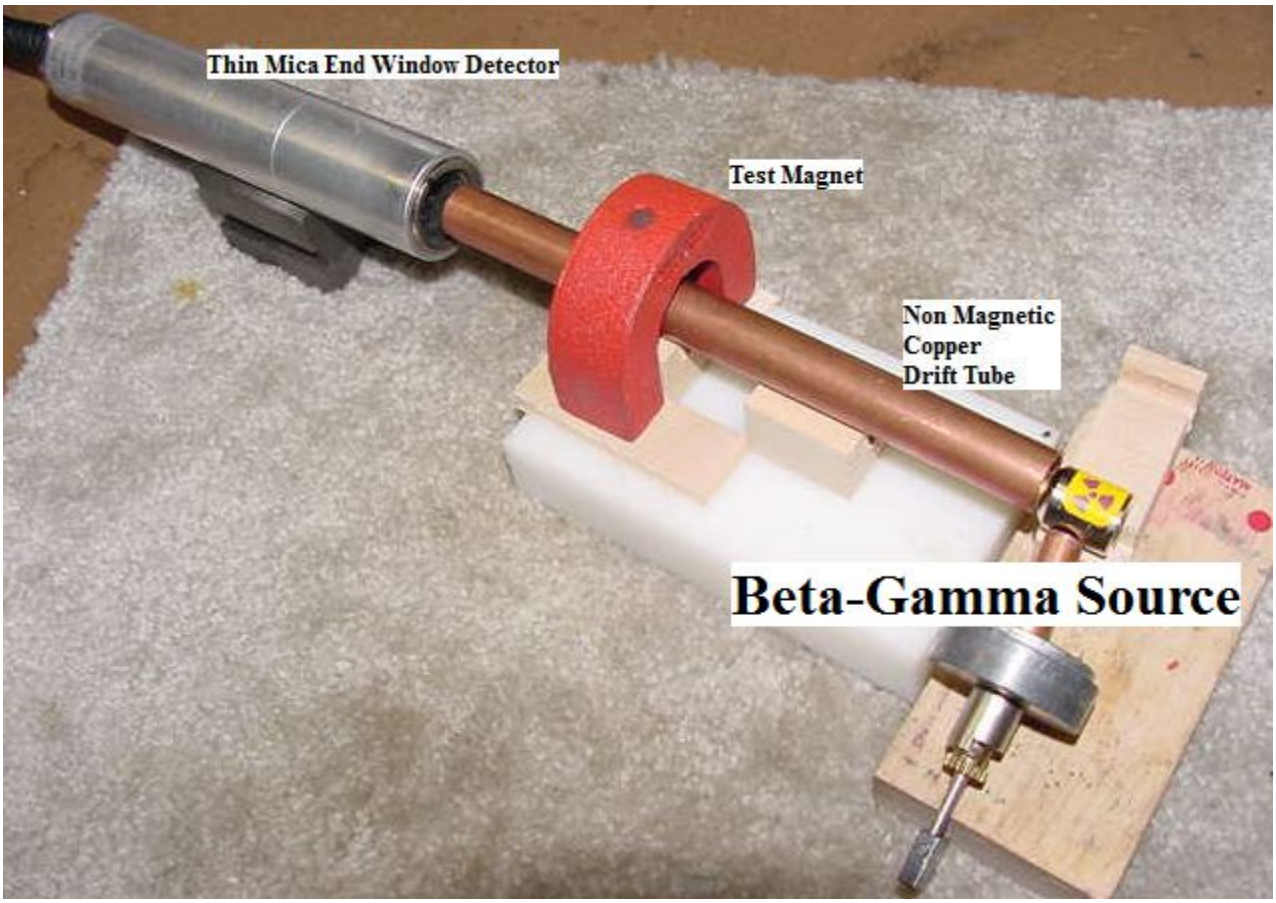
are not deflected by magnets. A thin lead absorber (C) blocks any stray beta particles from entering the gamma detector.

The other(E) detector responds only to the deflected beta particle.

Next is a slightly different setup using an end-window detector which is also sensitive to betas and gammas.

The radiation source has both betas and gammas. With the magnet we are able to deflect only the betas into the side of the drift tube so they do not enter the detector, only the gammas do. Removing the magnet allows both the betas and gammas to enter the detector. Reversing its polarity simply send the betas crashing into the opposite wall of the drift tube.

Betas can travel in air about 12 feet per MeV of energy they have. 1 MeV = 1000 keV.



Have fun,

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