Manganese-54 Radioactivity as a Novel Means for Detecting Nuclear Submarines

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Introduction

- One of Manganese's most stable radioactive isotopes is the Manganese 54 which has a half life of approximately 300 days.
- Claim: Neutrinos speed up Beta Decay in radioactive sources.
- When nuclear reactors are powered on they release upwards of ten billion neutrinos on average.
- Neutrino detection is difficult while Beta decay is not.
- Beta Decay could be used as a proxy, an alternative, to direct neutrino detection.
- If proven then there would be application with significant national security implications
- Detection of nuclear reactors by neutrino emissions
- Experiment 1, conducted near the High Flux Isotope Reactor of Oak Ridge National Laboratory,
- designed to address the question of whether a flux of reactor generated electron antineutrinos can alter the rates of weak nuclear interaction induced decays of 54Mn.
- A lead cave was constructed that consisted of two levels with four detectors on each level.
- An insulating box with 2inch thick polystyrene walls was built around the lead cave and maintained a stable temperature of ±20°C.
- experiment was designed to determine if when using an NaI detector you could tell when the reactor was on and active or when the reactor was off based upon the decay rate of the Manganese-54 source that was attached to the front of the detector.

Methods & Materials

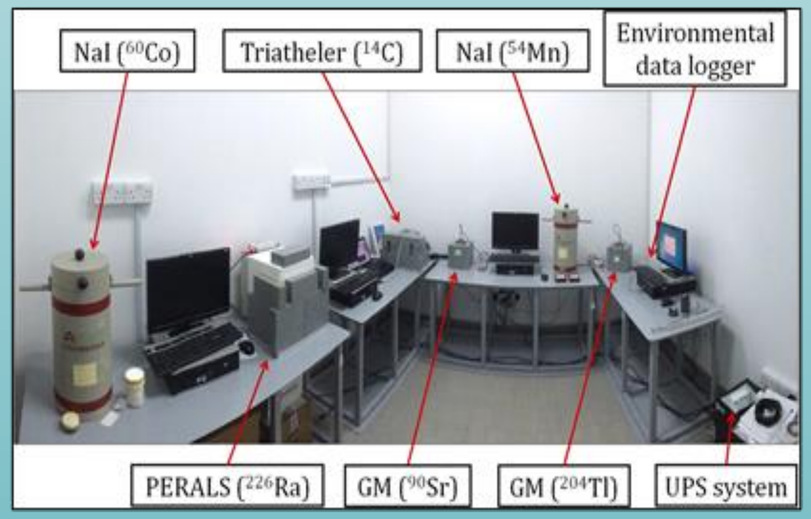

Figure 1: Laboratory setup highlighting important experimental equipment

- Figure 1 shows that for the experimental measurements, a dedicated counting room was setup on the third floor of the Khalifa University campus, Abu Dhabi, United Arab Emirates
- As Mn-54 beta decays it emits an 834.8keV gamma ray.
- causes the inside of the detector to give off photons of visible light
- These photons pass through a crystal which sits inside the detector and they strike a thin metal foil called a photocathode
- light enters the second part of the detector, called a photo-multiplier tube (PMT)
- , it causes an electron to be ejected from the photocathode.
- . If the neutrinos speed up the beta decay process, then the gamma decay process will also speed up
- more detections of the production of the 54Cr that Mn-54 decays to.
- detector to continuously record 30-minute interval measurements.

Results & Discussion

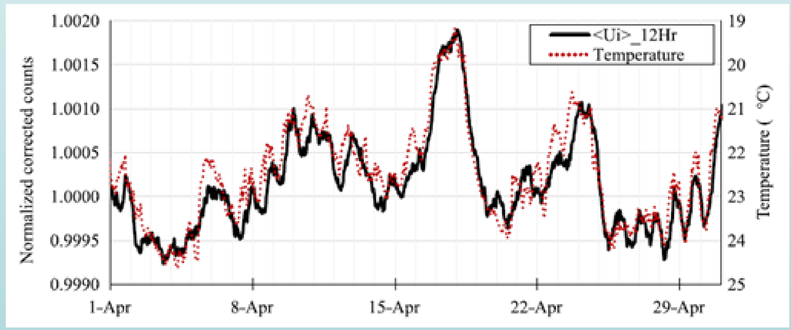

Figure 2: These results show the counts of a Manganese 54 source over a thirty day period

- Figure 2 confirms high probability that the 54Mn counts and temperature are correlated
- as temperature increases counts decrease.
- figure 3 shows a red line at the bottom of the graphs signifies when the reactor was on and when the reactor was off.
- researchers were looking to see that if when the red line was shifted up meaning the detector was on they would notice a significant fluctuation in the detected count rate compared to when the detector was off.
- not able to tell by looking at the data whether the reactor is on or off based on the decay rate of the Mn-54 source
- . They attribute the unknowns to what they think are three systematic errors.
- Experiment one looked to determine if neutrinos affected the rate of change of the decay process
- Experiment two's results were to say that there could be other underlying reasons as to why experiment one was getting this result.

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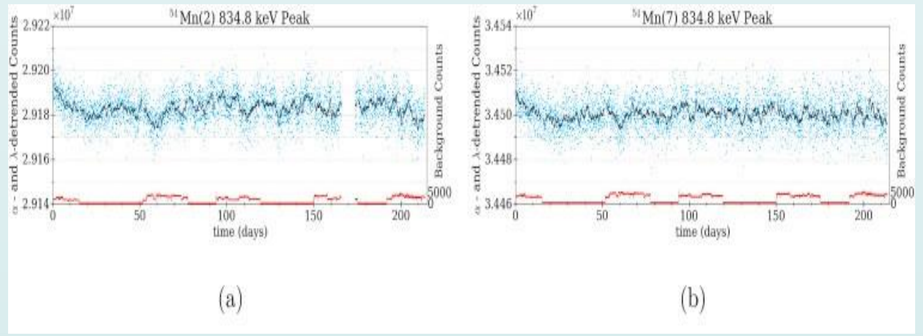

Figure 3: Exponentially- and α-detrended hourly counts vs. time, [and the full vertical fractional intervals for]: (a) 54Mn Det.2 [2.7×10−3] (b) 54Mn Det.7 [2.3×10−3]

Conclusions

- an increase of neutrinos through a radioactive isotope does not affect the rate at which the source decays.
- The results of the fluctuation in the counts is caused by other outside factors that do not correlate to neutrinos and the decay rate of a radioactive source.
- If more experiments were to be done and it was proven to be true that neutrinos passing through a radioactive source does affect the rate of decay then you may be able to use it as a means of detecting nuclear submarines.
- If proven then a detector on a submarine may be able to detect an increase in the decay rate of a radioactive source then they may be able to locate the cause (enemy submarine)

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***Acknowledgments**: I would like to thank both Dr. Monica Gray and Dr. George Hitt for both of their advice, input and knowledge*