Measuring Positron Annihilation Using NaI(Tl) Detectors

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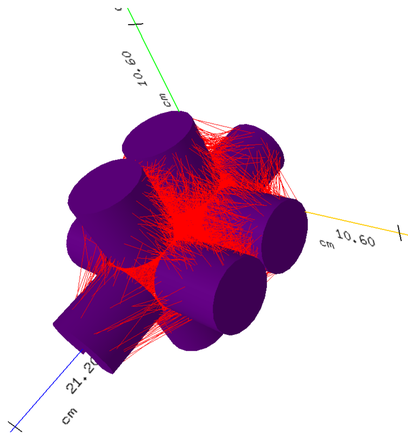
Motivation

- To identify sources of 511keV gamma rays and their respective contributions to detected 511keV gamma spectrum
- To obtain a detailed understanding of the gamma background radiation
- To identify Compton scattered 511keV gammas originating from the source

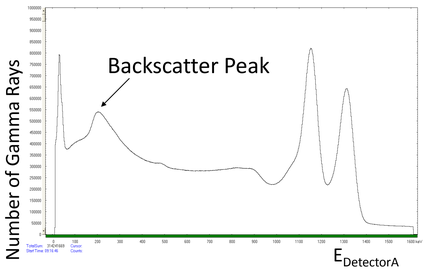
Testing using Radioactive Copper

- Activated copper will be used until a convenient source of radioactive carbon can be obtained
- It has a ~12.7 hr half-life so the decay process can be observed

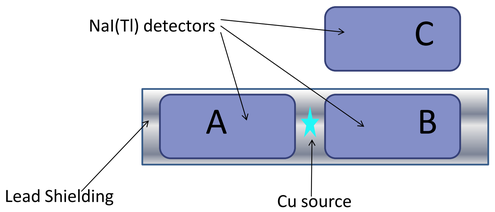


Primary Causes of Secondary Radiation

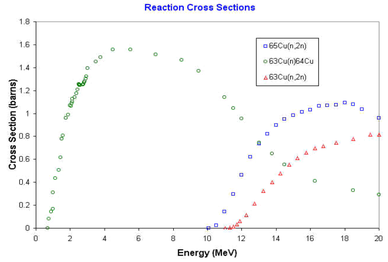
1. Characteristic X-rays
2. Backscatter Peaks
3. Annihilation Radiation
4. Ambient Radiation from concrete

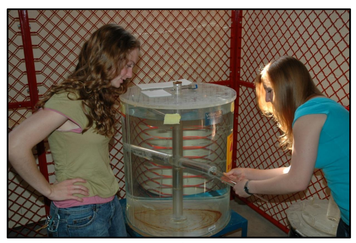


Experimental set-up of Cu detection

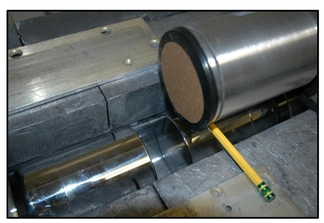


Pu —α— ^{9}Be— ^{12}C +n

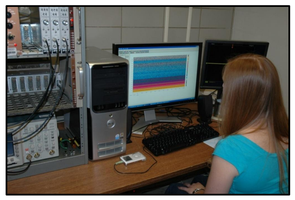




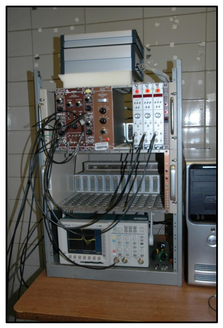
Geneseo's neutron howitzer (PuBe source) was used to irradiate the copper sample via the 63Cu(n)64Cu reaction.

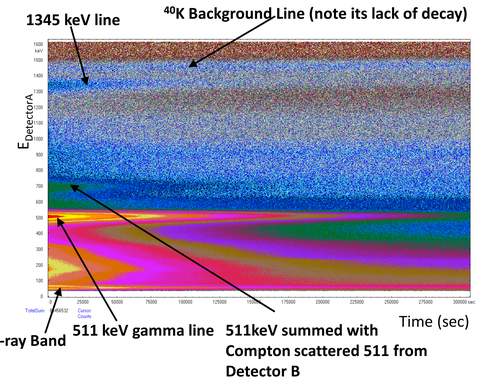


Three NaI detectors were connected to the MPA 2 fully encased in lead. The source was typically inserted in between the two detectors encased in the lead.

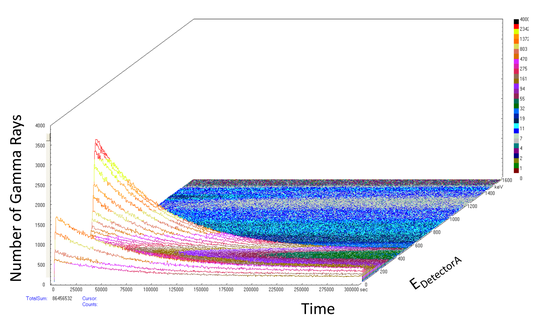


Three Standard NaI detectors with ORTEC PMT preamps model were connected to an ORTEC XXX amplifier. The amplifier signals were then passed to three 100,000 Kilo-samples/sec Wilkinson ADCs. Then processed in a multi-parameter data acquisition system (FastComTec MPA system)

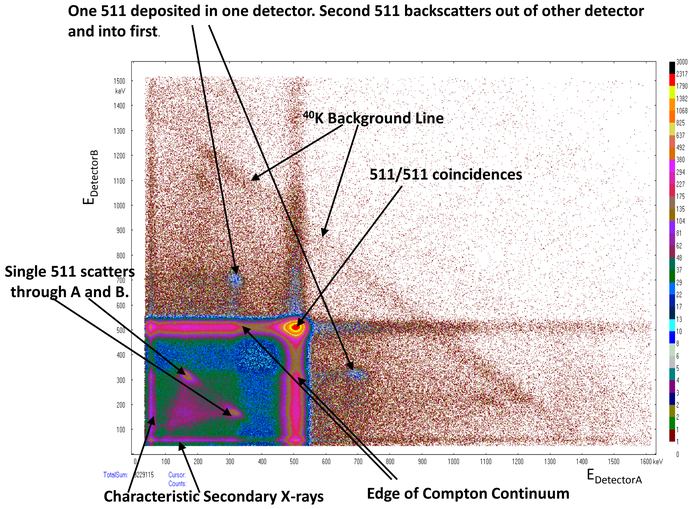




The gamma energy in Detector A vs. time is shown above. The decay of copper is readily seen in the narrow yellow-purple horizontal chevrons. The decay curve seen below, confirms that the gamma rays are produced from the source and are not a background artifact .

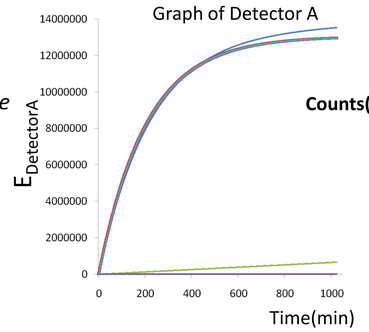


Coincidence Spectra of Cu for Detector A and B

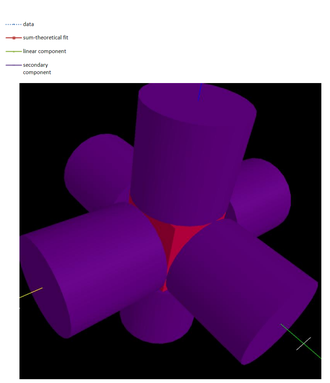


A gamma-gamma energy coincidence plot of detector B vs. detector A is shown above. The number of coincident counts at a given E_A vs. E_B location were scaled to a color and graphed by the MPA.

511 keV Band Converted to Display the Growth of Daughter Cells in Cu from a Real time Graph of Detector A

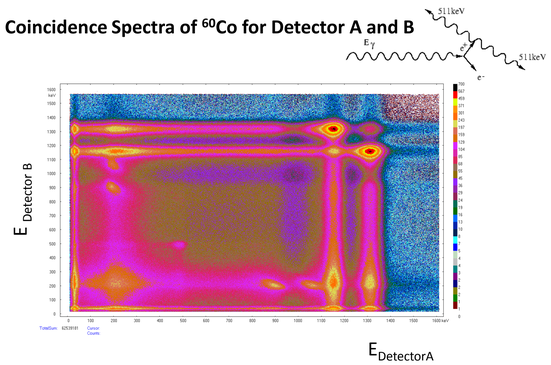


Counts(t)= $at+a_2(1-e^{(-\lambda_1 t)}) + b(1-e^{(-\lambda_2 t)})$



^{60}Co gamma rays Compton scattered off the detector walls or the lead shielding at very large angles. The remaining energy deposited in the detector created a backscatter peak.

Coincidence Spectra of ^{60}Co for Detector A and B



^{60}Co is not a positron emitter however, during its decay it produces 1170 keV and 1332 keV gamma rays, both have sufficient energy to pair produce(>1022 keV) .

Future research

- To identify all gamma coincidences in the 2-D spectrum
- To identify the proportion of 511keV single gamma ray counts to coincidence counts
- To construct a new full-capture Gamma-gamma system with 6 and 10 NaI detectors.