

DETERMINING CONVERSION ELECTRON YIELDS IN A
LIQUID SCINTILLATION SYSTEM

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Conversion electrons are monoenergetic electrons resulting from an alternative mode of decay to gamma ray emission. The energy of the conversion electron, E_e , is given by the equation:

$$E_e = E_\gamma - B.E._e$$

where E_γ is the energy of the gamma ray and $B.E._e$ is the binding energy of the electron in the extra-nuclear electron shell.

These electrons are counted with 100% efficiency provided the energy is sufficiently above the threshold of detection (which in low quenched solutions is only a few KeV).

Cobalt-57

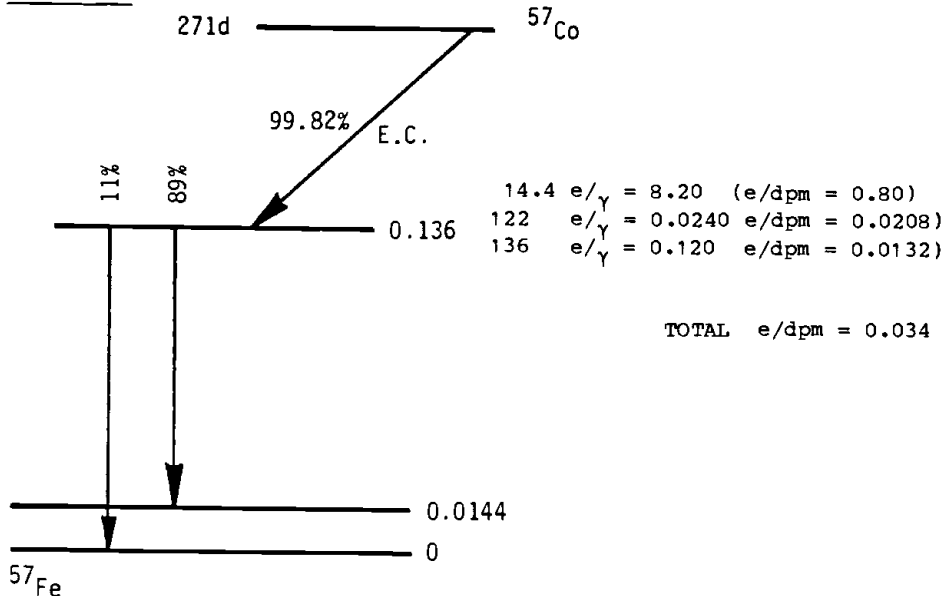


Figure 1. Decay Scheme of ^{57}Co .

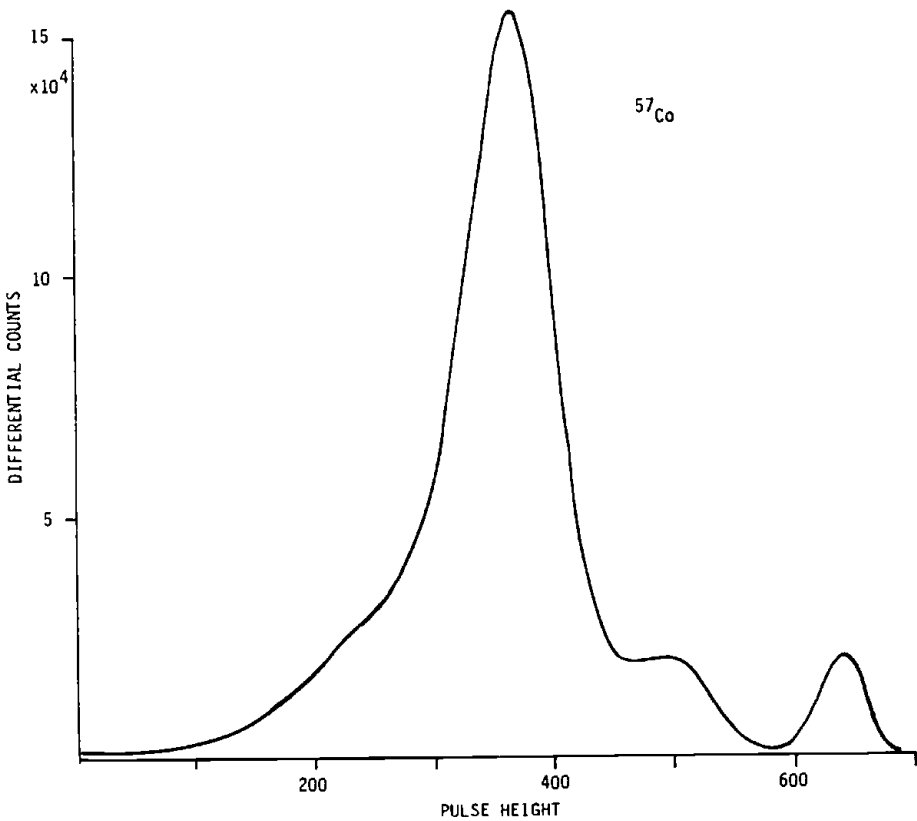


Figure 2. Pulse Height Spectrum of ^{57}Co .

The ^{57}Co decay scheme¹ is shown in Figure 1. The 136 KeV transition to ground occurs 11% of the total decays and of these, 12.0% give rise to a conversion electron. The yield of conversion electrons by this mode is given by:

$$(0.11) (0.12) = 0.0132 \text{ per dpm}$$

The 122 KeV + 14.4 KeV transitions to ground occur 89% of the total decays. The 14.4 KeV transition produces conversion electrons about

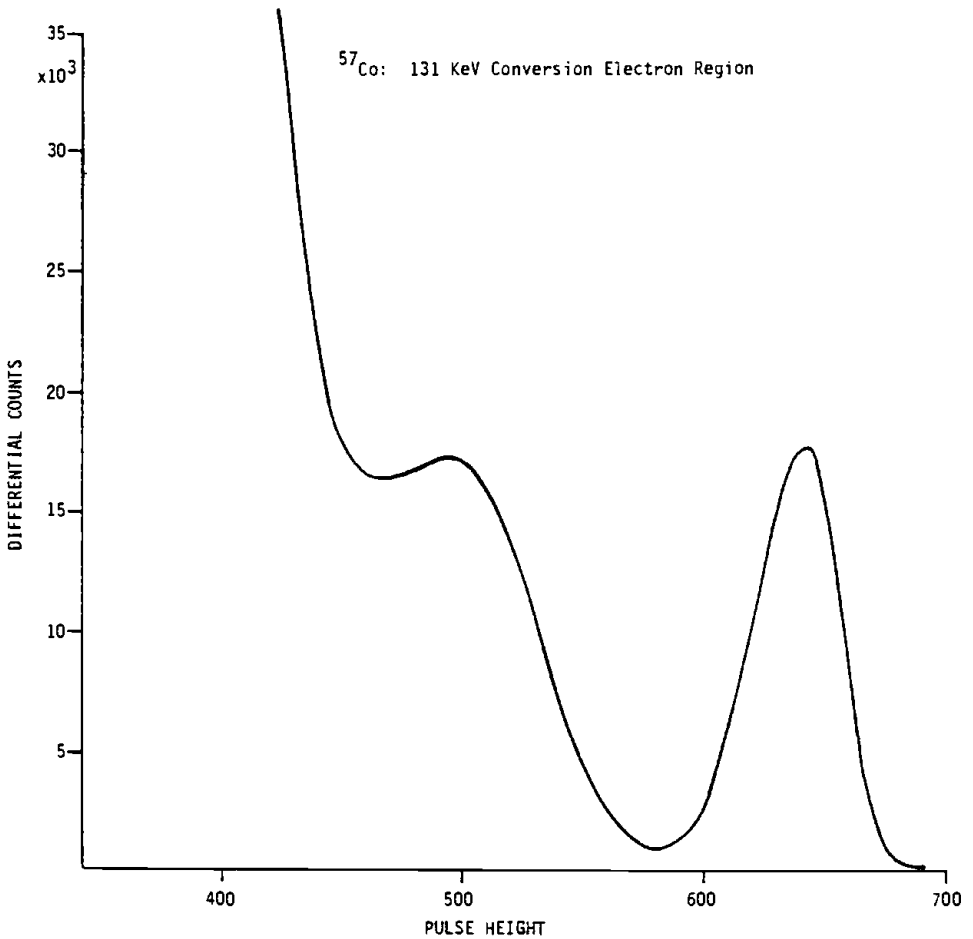


Figure 3. Pulse Height Spectrum of Conversion Electron Part of ⁵⁷Co Spectrum.

90% of the time. The 122 KeV transition produces conversion electrons 2.34% of the time. Essentially, every 122 KeV transition conversion electron will be coincident with the 14.4 KeV transition conversion electron. The yield of conversion electrons by this mode is given by:

$$(0.89) (0.0234) = 0.0208 \text{ per dpm}$$

The total yield of conversion electrons in ^{57}Co decay is:

$$0.0132 + 0.0208 = 0.0340 \text{ per dpm}$$

Figures 2 and 3 show the pulse height spectrum for ^{57}Co in a liquid scintillation solution. Figure 3 is an expanded plot of the conversion electron peak of the spectrum. The number of conversion electrons is obtained by summing the area of the conversion electron peak. The same sample was counted in a calibrated gamma counter with a 78% counting efficiency for ^{57}Co . The sample was calculated to have 7.26×10^5 dpm. The sample was counted in the LS system for 17.25 minutes, which means that 1.253×10^7 total disintegration occurred. The area of the conversion electron peak was 4.15×10^5 counts. The conversion electron yield calculated to be:

$$\begin{aligned} \text{Yield} &= \frac{4.15 \times 10^5 \text{ Conversion Electrons}}{1.253 \times 10^7 \text{ Total Decays}} \\ &= 0.0331 \text{ per dpm} \end{aligned}$$

The calculated yield (0.0331) agrees very well with the reported¹ yield (0.0340).

Chromium-51

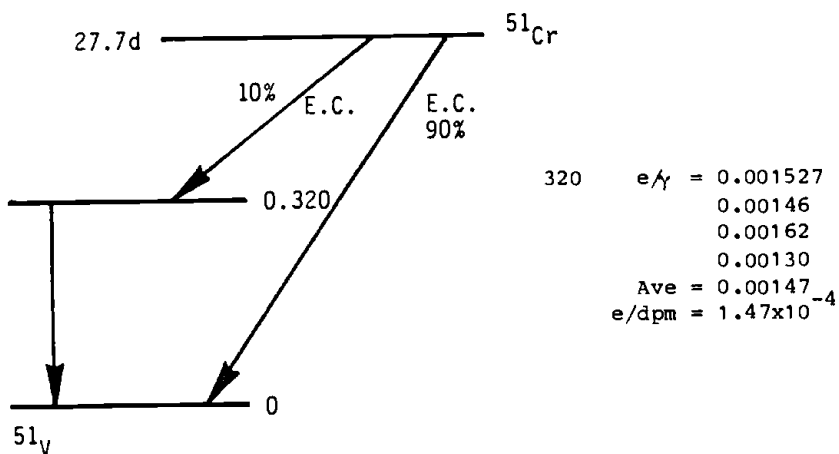


Figure 4. Decay Scheme of ^{51}Cr .

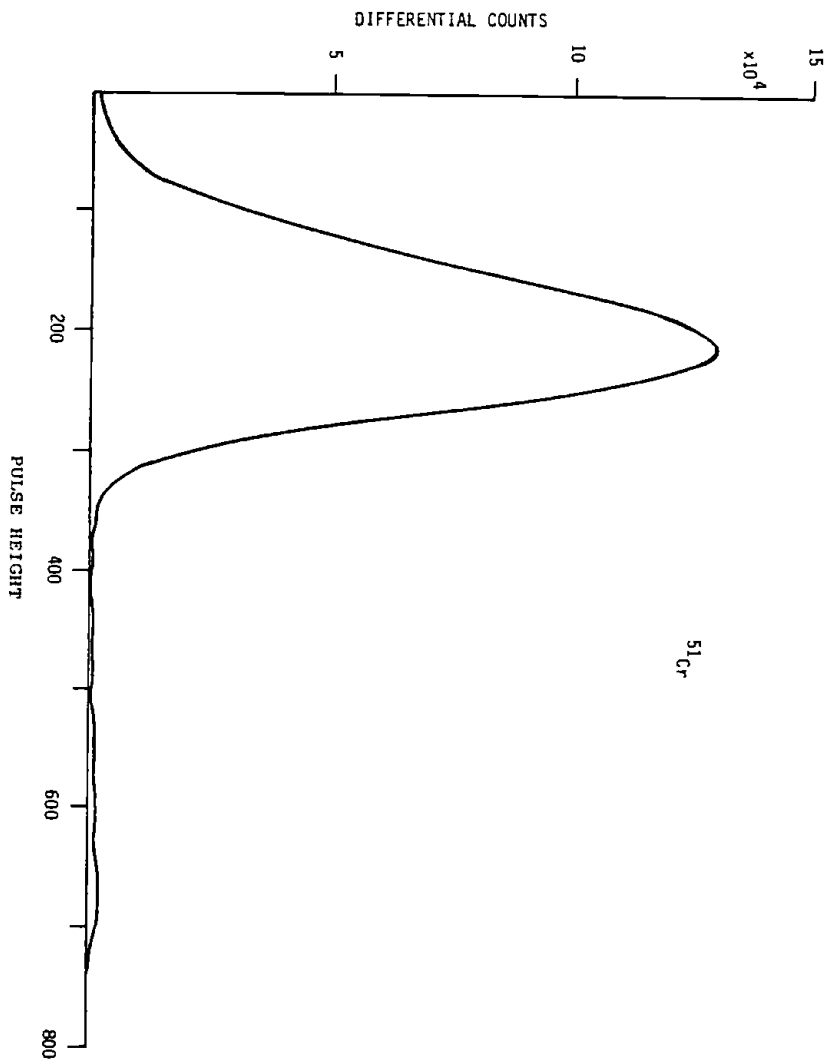


Figure 5. Pulse Height Spectrum of ^{51}Cr .

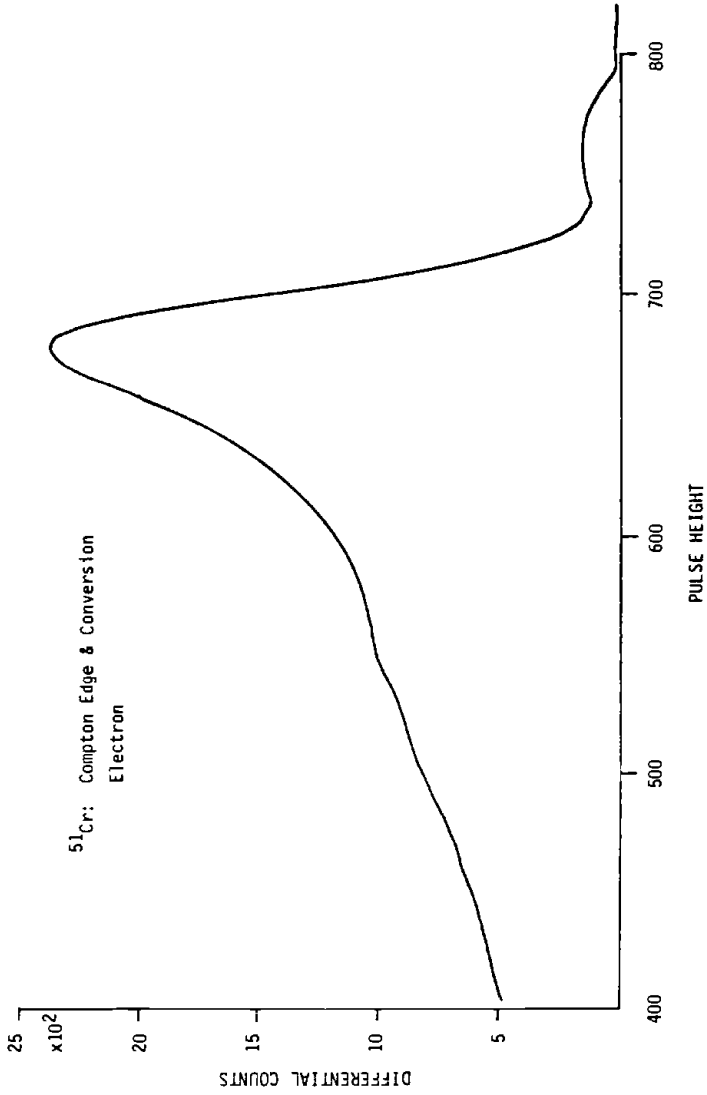


Figure 6. Pulse Height Spectrum of Part of ^{51}Cr Spectrum Showing Compton Edge and Conversion Electron.

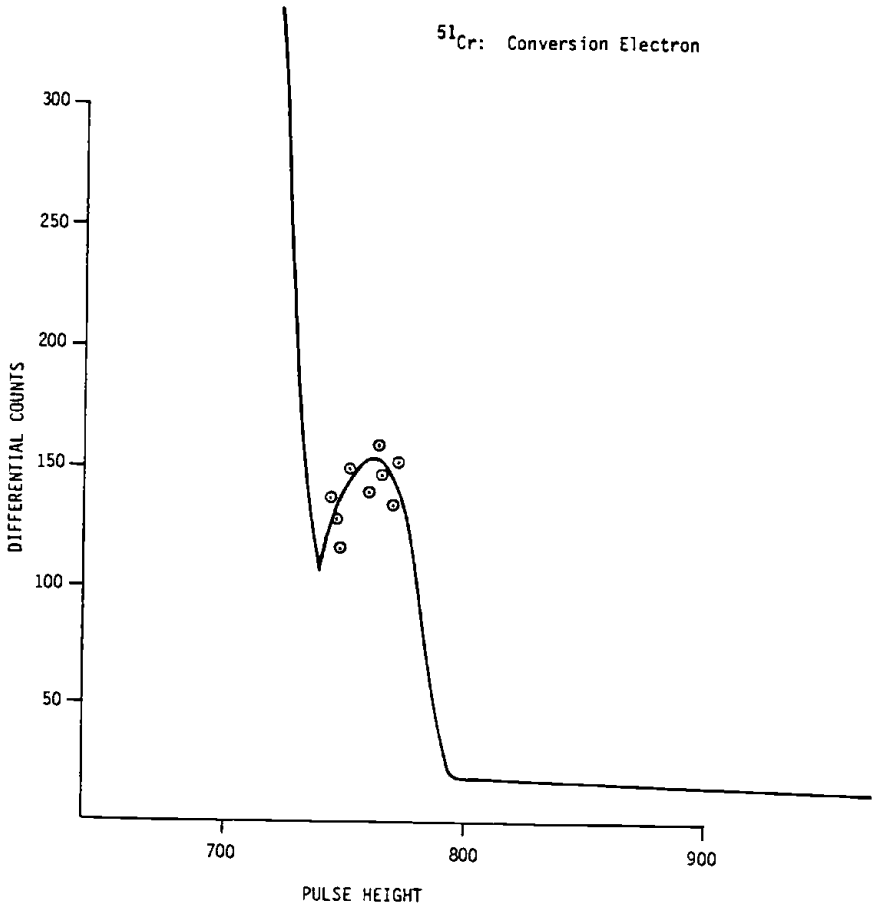


Figure 7. Pulse Height Spectrum of Part of ^{51}Cr Spectrum Showing the Conversion Electron.

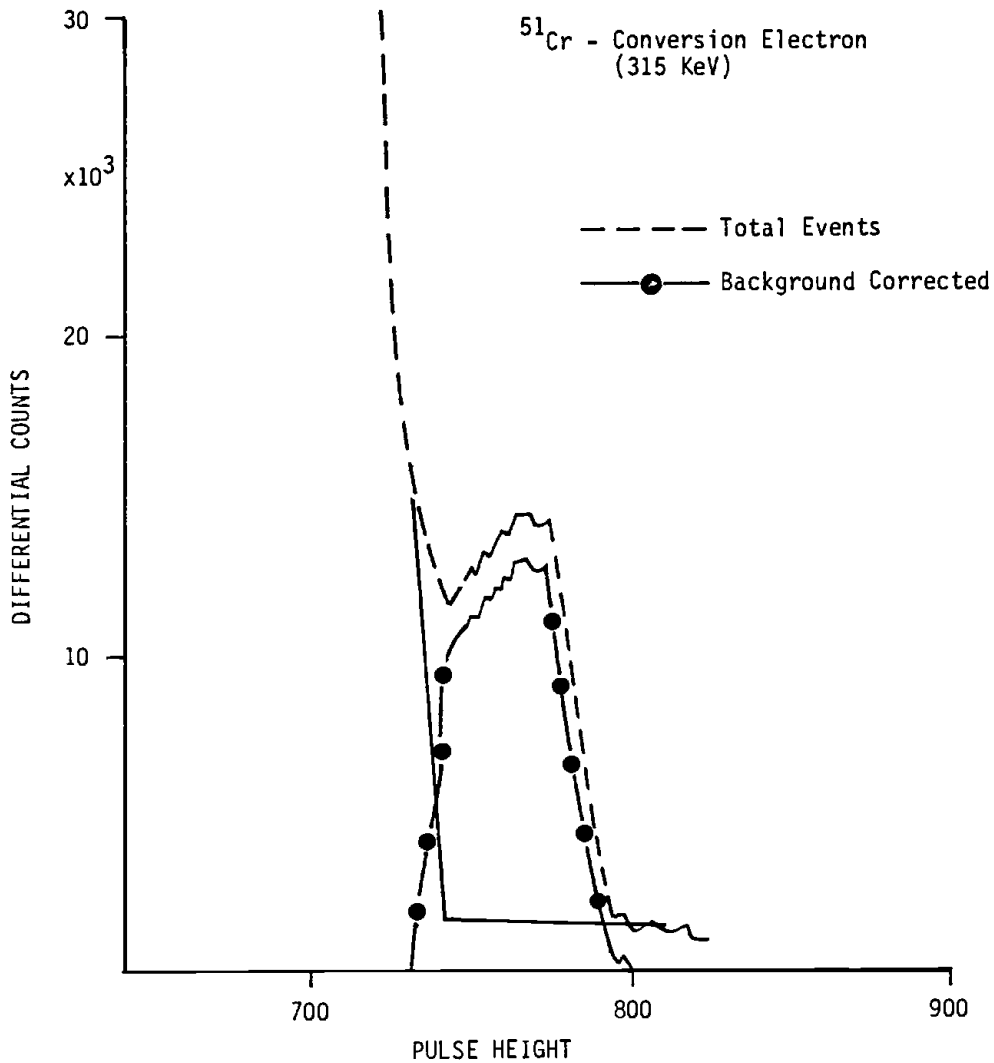


Figure 8. Pulse Height Spectrum of ^{51}Cr Conversion Electron Showing Subtraction of Background and Compton Edge.

The ^{51}Cr decay scheme¹ is shown in Figure 4. The 320 KeV transition to ground occurs 10% of the total decays and of these, approximately 0.147% give rise to a conversion electron. The yield of conversion electrons by this mode of decay is:

$$(0.00147) (0.10) = 1.47 \times 10^{-4} \text{ per dpm}$$

Figures 5-7 show the pulse height spectrum for ^{51}Cr in a liquid scintillator solution. Because of the very low conversion electron yield, the sample was counted 10 times and Figure 8 shows the summed result of those measurements. The background and tail of the Compton edge are subtracted, giving the resultant conversion electron peak.

The total counts accumulated were 9.013×10^7 , which at 45% counting efficiency, corresponds to 2.003×10^8 disintegrations. The number of conversion electrons (area of conversion electron peak) were 2.717×10^4 . The resultant yield was:

$$2.717 \times 10^4 / 2.003 \times 10^8 = 1.36 \times 10^{-4} \text{ per dpm}$$

The measured yield (1.36×10^{-4} per dpm) agrees quite well with the reported¹ yield (1.47×10^{-4} per dpm).

CONCLUSIONS

These results demonstrate the capabilities of a liquid scintillation system to measure conversion electron yields. The conversion electrons being monoenergetic, can be measured with 100% efficiency if the energy is significantly greater than the threshold (a few KeV for unquenched samples).

REFERENCE

1. In "Table of Isotopes" Seventh Edition, C.M. Lederer and V.S. Shirley (eds.), John Wiley & Sons, New York (1978).