Equipment Needed from ORTEC

• Two 113 Scintillation Preamplifiers
• 4001A/4002D Bin and Power Supply
• 414A Fast Coincidence
• 416A Gate and Delay Generator
• 427A Delay Amplifier
• Two 556 High Voltage Power Supplies
• 480 Pulser
• 974 Quad Timer/Counter
• Two 575A Amplifiers
• Two 551 Timing Single-Channel Analyzers
• Two 905-3 NaI(Tl) 2- x 2-in. Detectors with Phototubes
• Two 266 PMT Bases
• Easy-MCA 2k System including a USB cable, a suitable PC and MAESTRO-32 software (other ORTEC MCAs may be substituted)
• Coaxial Cables and Adapters:
    • Two C-36-12 RG-59B/U 75-Ω cables, with two SHV female plugs, 3.7-m (12-ft) length.
    • One C-25-2 RG-58A/U 50-Ω cable, with BNC plugs, 0.61-m (2-ft) length.
    • Two C-24-1/2 RG-62A/U 93-Ω cables, with BNC plugs, 15-cm (1/2-ft) length.
    • Eight C-24-2 RG-62A/U 93-Ω cables, with BNC plugs, 0.61-m (2-ft) length.
    • Two C-24-4 RG-62A/U 93-Ω cables, with BNC plugs, 1.2-m (4-ft) length.
    • Four C-24-12 RG-62A/U 93-Ω cables, with BNC plugs, 3.7-m (12-ft) length.
    • Two C-29 BNC Tee Connectors.

Equipment Required from Other Manufacturers

• Oscilloscope (bandwidth ≥100 MHz).
• 10 µCi ^{60}Co gamma-ray source.
• Gamma-Gamma Angular Correlation Table with fixed and rotating shielded mounts for the detectors (see Appendix)
• A small flat-blade screwdriver for adjusting screwdriver-accessible controls, or an equivalent potentiometer adjustment tool.

Purpose
In this experiment the coincidence technique outlined in Experiments 9 and 13 will be used to study the gamma decay of ^{60}Co. Angular correlation concepts will also be introduced.

Introduction
There are two parts to Experiment 19: 1) a gamma-gamma coincidence experiment that will be performed to show that the two gamma-rays from ^{60}Co are in coincidence, and 2) measurement of the angular correlation of these two gamma-rays, determination of the anisotropy, and the coefficients of the correlation function. The decay scheme for ^{60}Co is shown in Fig. 19.1.

Note in Fig. 19.1 that ^{60}Co beta decays to the 2.507-MeV level of ^{60}Ni, and this de-excites by a gamma-ray cascade through the
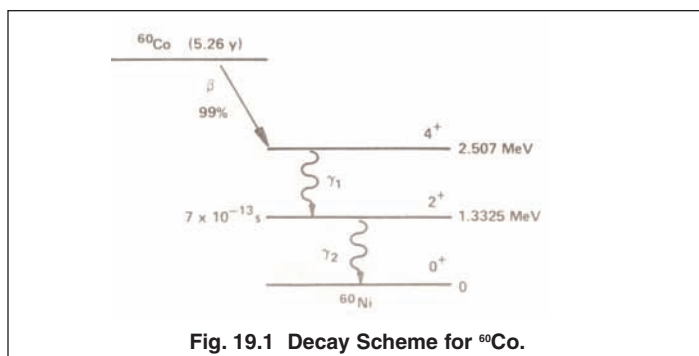

Fig. 19.1 Decay Scheme for ^{60}Co.

1.3325-MeV state. Because the lifetime of the 1.3325-MeV state is only 0.7 ps, the two gamma-rays will appear to be in coincidence experimentally. Figure 19.2 shows a NaI(Tl) spectrum from ^{60}Co.
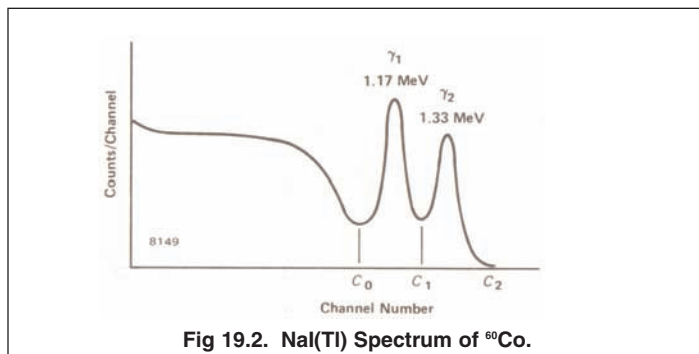

Fig 19.2. NaI(Tl) Spectrum of ^{60}Co.

In order to verify that γ_1 and γ_2 are in coincidence, it is necessary to use the experimental techniques that were outlined in Experiment 13. Figure 19.3 shows the geometrical setup that will be used for both the $\gamma_1-\gamma_2$ coincidence verification and the angular correlation measurement in this experiment.
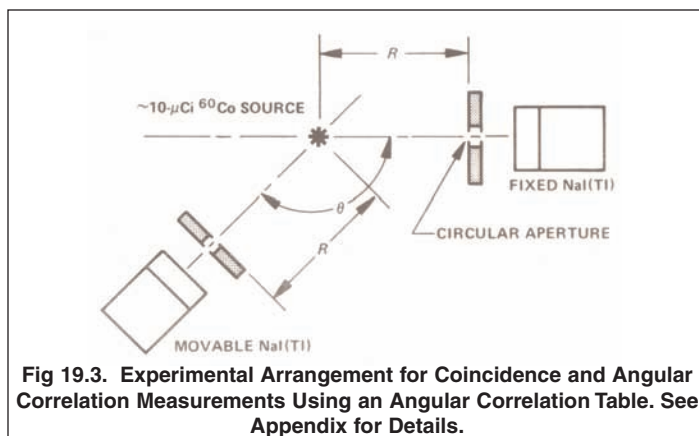

Fig 19.3. Experimental Arrangement for Coincidence and Angular Correlation Measurements Using an Angular Correlation Table. See Appendix for Details.

Since the angular correlation of γ_1 and γ_2 is nearly isotropic, the angle θ in Fig 19.3 can be set at any value for the coincidence verification. Usually, the most convenient angle is 180°. A typical electronics setup for the measurement is shown in Fig 19.4.
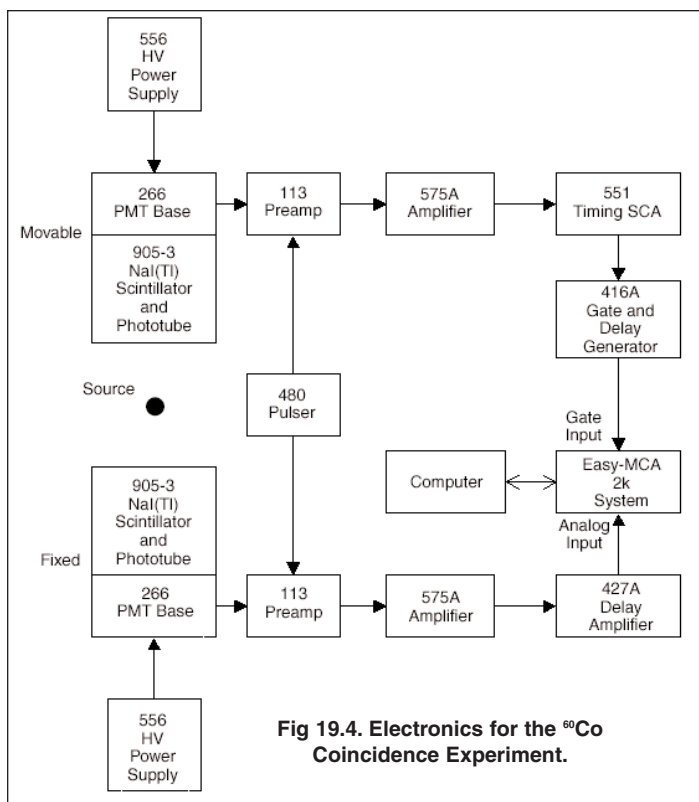
ORTEC®

AN34 Experiment 19
A Study of the Decay Scheme
and Angular Correlation of ^{60}Co

Fig 19.4. Electronics for the ^{60}Co Coincidence Experiment.

EXPERIMENT 19.1

Verification of the Gamma-Gamma Coincidence for ^{60}Co

Procedure

1. Set up the electronics as shown in Fig. 19.4. Ensure the NIM bin power and the HV Power Supplies are turned off. The details for cable connections and instrument settings are outlined below. For both detectors and their chain of signal processing electronics, implement the following steps.

   a. Connect the ANODE output of the 266 PMT Base to the INPUT of the 113 Scintillation Preamplifier using a 15-cm C-24-1/2 RG-62A/U 93-Ω cable. Set the INPUT CAPacitance switch on the 113 to zero.

   b. Connect the 113 Preamplifier power cable to the PREAMP POWER connector on the rear panel of the supporting 575A Amplifier. Check that the time constant switches accessible through the side panel of the 575A Amplifier are all set to 0.5 μs.

   c. Insert the 575A Amplifier and the related 556 HV Power Supply side-by-side into the NIM bin.

   d. Connect the 113 Preamplifier OUTPUT to the supporting 575A Amplifier INPUT using a 3.7-m C-24-12 RG-62A/U 93-Ω cable. Set the 575A input polarity to NEGative.

e. Using a 3.7-m C-36-12 RG-59B/U 75-Ω cable with two SHV female plugs, connect the OUTPUT of the related 556 HV Power Supply to the POS HV input of the 266 PMT Base. Check that the POLARITY switch on the rear panel of the 556 is set to POSitive, and the CONTROL toggle switch is set to INTernal. Set the front-panel voltage controls on the 556 to their minimum values.

f. Connect the Bipolar output of the 575A Amplifier to the analog INPUT of the Easy-MCA using a 1.2-m C-24-4 RG-62A/U 93-Ω cable.

g. Verify that the Easy-MCA is connected to the computer via the USB cable.

h. Turn on power to the NIM bin and the computer that supports the Easy MCA.

i. Position a ^{60}Co radioactive source in front of the NaI(Tl) detector.

j. Set the 556 high voltage to the value that is recommended for the related scintillation detector. Turn on the 556 HV POWER.

k. Set the 575A Amplifier gain for a bipolar output amplitude of approximately +6 V on the 1.33-MeV gamma-ray photopeak pulses, as observed on the 1-MΩ input of the oscilloscope. Check that the FOCUS control on the related 266 PMT base has been adjusted to maximize the above pulse height.

l. Reconnect the 575A BIpolar OUTput to the analog INPUT of the Easy-MCA.

m. Via the Acquire menu and the ADC tab in the MAESTRO-32 software that operates the Easy-MCA, select the Gate Off option, and adjust the Upper Level discriminator to its maximum value. Adjust the Lower Level discriminator as low as possible without causing excessive counting rate on the noise. It may be useful to temporarily turn off the 556 High Voltage for the Lower Level discriminator adjustment. Under the Preset tab, clear all data fields, and do the same for the MDA Preset option (if supported). Clearing those fields will default to manual control for starting and stopping spectrum acquisition. Select the analog-to-digital conversion range to be 1024 channels for a 0 to +10-V input. Familiarize yourself with the software controls for setting up, acquiring and erasing spectra.

n. Verify that the ^{60}Co peaks accumulate at circa 60% of full scale in the energy spectrum on the MCA. The spectrum should look like that shown in Fig. 19.2.

o. Connect the UNipolar OUTput of the 575A Amplifier to the 1-MΩ input of the oscilloscope. Set the horizontal scale of the oscilloscope to 50 μs/cm and the vertical scale to 100 mV/cm. With a small, flat-blade screwdriver, adjust the PZ ADJ on the 575A Amplifier to make the pulses on the UNIpolar OUTput return to baseline as quickly as possible without undershooting the baseline between pulses. For further guidance on this Pole-Zero Cancellation

ORTEC®

AN34 Experiment 19
A Study of the Decay Scheme
and Angular Correlation of ^{60}Co

adjustment, consult the instruction manual for the amplifier, or the introduction to the amplifier product family on the ORTEC web site at www.ortec-online.com.

2. Repeat the above steps 1a) through 1o) for the other NaI(Tl) detector and its signal processing electronics.

3. Determine which of the two 575A amplifiers has the higher gain setting. Using a 3.7-m C-24-12 RG-62A/U 93-Ω cable, connect the ATTENuated output of the 480 Pulser to the TEST PULSE input of the 113 Preamplifier associated with that higher gain amplifier. Using the same length of coaxial cable, connect the DIRECT output of the 480 Pulser to the TEST PULSE input on the other 113 Preamplifier.

4. Set the 480 Pulser output polarity to NEGative and turn on the pulser. Remove the ^{60}Co source.

5. Adjust the PULSE HEIGHT and/or CAL. Controls on the 480 Pulser so that the pulse height at the output of the lower-gain amplifier is approximately +4 V.

6. Adjust the ATTENUATOR toggle switches on the 480 Pulser so that the pulse height at the output of the higher-gain amplifier is within the range of +2 V to +8 V. If you cannot achieve this latter requirement, you may need to interchange the DIRECT and ATTENuated connections and repeat steps 5 and 6.

7. Identify the 575A Amplifier associated with the movable detector. Using a 0.61 m C-24-2 RG-62A/U 93-Ω cable, connect the BIpolar output of that amplifier to the DC INPUT of the 551 Timing SCA. On the SCA, select the NORmal mode and the 0.1 – 1.1 μs delay range. Adjust the DELAY dial to 0.5 μs. Check that the LL REF and STROBE toggle switches on the rear panel are both set to the INTernal mode. Set the UPPER LEVEL to maximum (10 V), and the LOWER LEVEL to 0.1 V.

8. Using a 0.61-m C-24-2 RG-62A/U 93-Ω cable, connect the 551 POSitive OUTput to the POSitive INPUT of the 416A Gate and Delay Generator.

9. Identify the 575A Amplifier that is associated with the fixed detector. Using a 0.61-m C-24-2 RG-62A/U 93-Ω cable, connect the Bipolar output of that amplifier to the input of the 427A Delay Amplifier.

10. Confirm that the Pulser is still turned on. Trigger the oscilloscope with the leading edge of the NEGative DELAYED OUTput of the 416A. Observe the POSitive DELAYED OUTput of the 416A on one input channel of the oscilloscope. Simultaneously, observe the analog pulse from the 427A Delay Amplifier OUTPUT on the second input channel of the oscilloscope.

11. Set the DELAY controls on the 416A to their minimum values. Adjust the 416A POSitive DELAYED OUTput logic-pulse amplitude to approximately +5 V.

12. Adjust the DELAY switches on the 427A Amplifier so that the beginning of the analog output pulse from the 427A arrives just after the leading edge of the logic pulse from the 416A.

The DELAY dial on the 416A can be used to fine tune this arrival relationship so that the analog pulse begins a few tenths of a microsecond after the logic pulse.

13. Adjust the WIDTH control on the 416A so that the logic pulse from the 416A overlaps the leading edge of the analog pulse and extends at least 0.5 microseconds past the maximum amplitude point (a longer duration is O.K.). See Fig. 19.5 for a pictorial representation of this gating relationship.

Fig. 19.5 Relationship of the Gating Logic Pulse from the 416A to the Positive Lobe of the Analog Signal from the 427A.
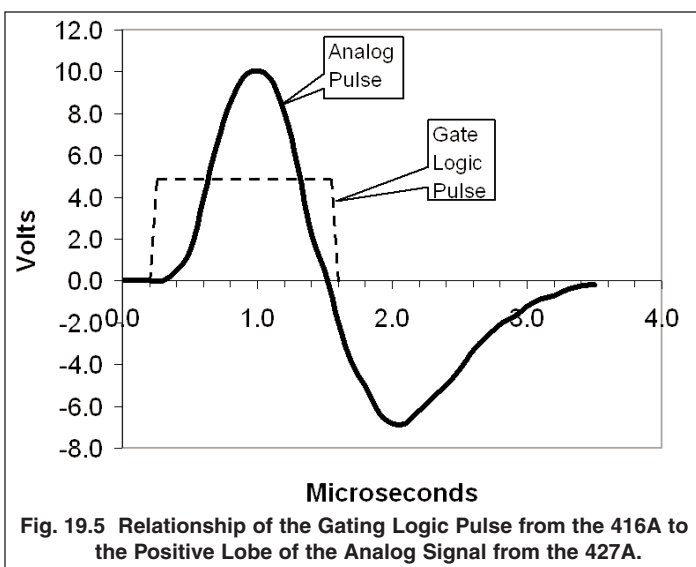
14. Using 1.2-m C-24-4 RG-62A/U 93-Ω cables, connect the POSitive DELAYED OUTput of the 416A to the GATE Input of the Easy-MCA, and connect the 427A OUTPUT to the analog INPUT of the Easy-MCA.

15. Verify that the Easy-MCA will accumulate the Pulser spectrum.

16. Via the Acquire menu and the ADC tab in the MAESTRO-32 software that operates the Easy-MCA, select the Gate On option. Confirm that the Easy-MCA will still acquire the Pulser spectrum.

17. Disconnect the 416A output from the Easy-MCA GATE input. Confirm that this prevents the acquisition of the pulser spectrum. Reconnect the 416A output to the Easy-MCA GATE input, and turn off the 480 Pulser.

18. Disconnect the 427A INPUT from the Fixed-detector 575A Amplifier BIpolar output. Connect the Movable-detector 575A Amplifier UNIpolar output to the 427A INPUT.

19. Place the 10-μCi ^{60}Co source in the mount half-way between the two detectors, and acquire a spectrum on the Easy-MCA. Identify the 1.17-MeV gamma-ray peak in the spectrum. Check that the Easy-MCA has the Gate On option selected in the MAESTRO-32 software controls.

20. Switch the 551 SCA to the WINdow mode. Raise the LOWER LEVEL control and lower the WINDOW dial until the gating provided by the 551 restricts acquisition on the Easy-

MCA to the 1.17-MeV peak. Make fine adjustments so that the acquired spectrum contains the complete 1.17-MeV peak, but excludes the 1.33-MeV peak and the Compton continuum. Lock the dials on the 551 at this setting. This setup ensures that the Easy-MCA will acquire a spectrum only when a 1.17-MeV gamma-ray has been detected in the movable detector.

21. Disconnect the 427A INPUT from the 575A UNIpolar output that is associated with the Movable-detector signal processing chain. Connect the 427A INPUT to the BIpolar output of the 575A Amplifier associated with the Fixed-detector signal processing chain.

22. Accumulate a spectrum in the MCA. This spectrum should include only the 1.33-MeV peak and its Compton continuum from the Fixed detector. The 1.17-MeV peak of Fig 19.2 will be virtually eliminated. This result shows that the 1.17- and 1.33-MeV gammas are in coincidence, because a 1.17-MeV gamma-ray was required in the SCA in order to acquire each 1.33-MeV pulse in the spectrum.

23. Repeat the experiment with the 551 Timing SCA set to bracket the 1.33-MeV peak. Under these conditions, only the 1.17-MeV peak and its Compton continuum should appear in the MCA spectrum. These two measurements verify that γ_1 and γ_2 in Fig 19.1 are prompt, sequential gammas. Experiment 19.2 describes the procedure necessary for studying their angular correlation.

EXPERIMENT 19.2

Angular Correlation of ^{60}Co

The Table of Isotopes (ref. 4) gives the spins of most of the nuclear levels that have been measured. Many of these spin assignments were made on the basis of angular correlation measurements. In the case of gamma-gamma angular correlation, an experimental arrangement similar to Fig. 19.3 is used. The fixed detector is set to measure only γ_1, and the movable detector observes γ_2. The number of coincidences between γ_1 and γ_2 is determined as a function of θ (the angle between the two detectors). A plot of the number of coincidence events per unit time as a function of the angle, θ, is called the measured angular correlation. The detection of γ_1 in a fixed direction selects nuclei for which the subsequent γ_2 emissions have a non-isotropic angular distribution. This is a result of the non-isotropic distribution of spin orientations in ^{60}Co. Figure 19.1 shows that ^{60}Co beta decays to the 2.507-MeV, (4+), state which cascades through the 1.3325 MeV, (2+), state to the ground state, (0+), of ^{60}Ni. The numbers in parentheses in the previous sentence, e.g. (4+), denote the spins for the specific states.

These angular momenta (spins) determine the shape of the correlation function of the isotope. A complete discussion of the theoretical arguments associated with the angular correlation measurements is presented in ref. 1 and 2. The theoretical correlation function, $w(\theta)$, for ^{60}Co is given by

$$w(\theta) = a_0 + a_2 \cos^2\theta + a_4 \cos^4\theta \qquad (1)$$

where $a_0 = 1$, $a_2 = 1/8$, and $a_4 = 1/24$.

Table 19.1 shows the calculated values for $w(\theta)$ for angles between 90° and 180° in 10° increments for ^{60}Co.

Table 19.1 Angular Correlation Function $w(\theta)$ for ^{60}Co.	
θ (deg)	$w(\theta)$
90	1.00000
100	1.00381
110	1.01519
120	1.03385
130	1.05876
140	1.08770
150	1.11719
160	1.14287
170	1.16042
180	1.16667

It can be seen from Table 19.1 that the correlation function, $w(\theta)$, changes by only 17% from 90° to 180°. Therefore, ~1% counting statistics[†] should be targeted when the experiment is performed.

The anisotropy, A, associated with an angular correlation measurement is defined as

$$A = \frac{w(180°) - w(90°)}{w(90°)} \qquad (2)$$

A comparison of the experimental anisotropy with the theoretical value will reveal that angular correlation measurements are capable of rather high precision.

In this experiment the experimental angular correlation, $w(\theta)$, will be compared to Eq. (1) and the values shown in Table 19.1. Additionally, the calculated and measured anisotropy will be compared to Eq. (2).

Procedure

1. Starting with the setup in Fig. 19.4, ensure that procedure steps 1 through 7 of Experiment 19.1 have been completed.

2. Modify the electronics setup to match Fig. 19.6. More specifically:

   a. Turn off the NIM Bin power and the HV power supplies.

   b. Remove the two 556 High-Voltage Power Supplies from the bin to make room to insert another 551 Timing SCA, the 414A Fast Coincidence and the 974 Quad Timer/Counter modules. Reconnect the power cords for the 556 HV supplies to the 117 V ac power source. (The 556 HV power supplies do not have to be mounted in the bin to perform their function.)

   c. Ensure that the settings on both 551 Timing SCAs are identical to those in step 7 of Experiment 19.1.

   d. Make sure that both 575A Amplifiers have their BIpolar output connected to the DC INPUT of their associated 551 Timing SCA. Use 0.61-m C-24-2 RG-62A/U 93-Ω cables for these two connections.

[†]If N counts are accumulated in a live time t_L, the estimated percent standard deviation in the counts is 100%/$N^{1/2}$. Therefore, 1% statistics requires N = 10,000 counts.
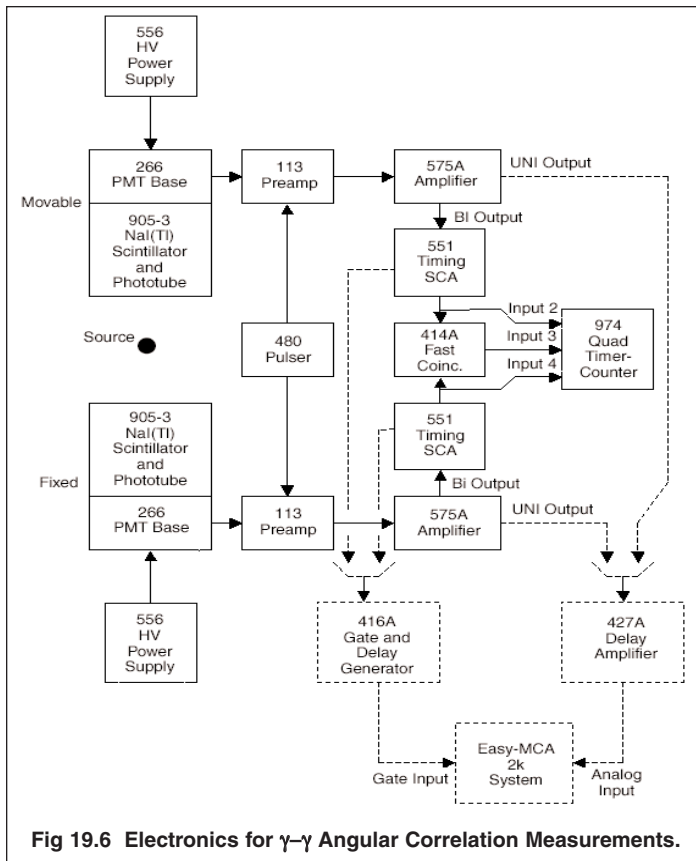
ORTEC®

AN34 Experiment 19
A Study of the Decay Scheme
and Angular Correlation of ^{60}Co

Fig 19.6 Electronics for γ–γ Angular Correlation Measurements.

e. Place BNC Tees on COINC inputs A and B of the 414A Fast Coincidence module. Turn the A and B switches to IN, and switches C and D to OUT. Set the RESOLVING TIME dial to 100 ns.

f. Using 0.61-m C-24-2 RG-62A/U 93-Ω cables, connect the POS OUTput of the 551 Timing SCA associated with the movable detector to the BNC Tee on the A COINC input of the 414A. Similarly, connect the POS OUTput of the 551 Timing SCA associated with the fixed detector to the BNC Tee on the B COINC input of the 414A.

g. Using 0.61-m C-24-2 RG-62A/U 93-Ω cables, connect the Tee on the A COINC input of the 414A to COUNTER INPUT 2 of the 974. Similarly, connect the Tee on the B COINC input of the 414A to COUNTER INPUT 4 of the 974. Connect one OUTPUT of the 414A to COUNTER INPUT 3 of the 974.

h. The dashed lines in Fig. 19.6 will be used for tuning the SCAs to select the 1.17-MeV and 1.33-MeV gamma-ray peaks from their respective detectors.

3. On the 974 Quad Timer-Counter, turn the DWELL knob to its maximum clockwise position. This will ensure the counts are displayed for approximately 15 seconds before resetting and starting a new counting interval.

4. Push the TIME BASE SELECT button to select the 0.1-SEC. time base. Push the M PRESET button to select M=1. Push

the N button to choose N=1. This will set a preset counting time of 0.1 s x M x 10^N = 1 second. Press the DISPLAY SELECT button to choose displaying counter 1 on the top display. In sequence, press the STOP, RESET then COUNT buttons. Counter 1 should accumulate up to 10 counts (1 second) pause for 15 seconds, then reset and repeat the cycle.

5. Remove the ^{60}Co source and turn on the 480 Pulser. Select Counter 2 for display on the 974. Confirm that Counter 2 accumulates 60 counts in 1 second, displays that result for approximately 15 seconds, then resets to zero and repeats the cycle. (If the ac line frequency is different from 60 Hz, then the number displayed should be identical to the line frequency.)

6. Repeat step 5, while displaying Counter 4.

7. Select Counter 3 for display. Adjust the DELAY dial on either 551 SCA to maximize the counting rate from Input 3 on the 974 Quad Timer-Counter. This maximum should be 60 counts for a 60-Hz ac line frequency, (or at least equal to your line frequency, if not 60 Hz). If there is a range of DELAY settings for which the counting rate is 60 counts/s in counter 3, choose the final DELAY setting at the middle of this range. This step ensures that the delays are the same from the input to each preamplifier through to the input to the 414A Coincidence module. Lock the DELAY dials on both 551 SCAs to avoid changing this adjustment.

8. Turn off the 480 Pulser and place the 10-μCi ^{60}Co source in the mount half way between the two detectors.

9. Identify the 551 SCA that serves the fixed detector.

a. Connect the NEGative OUTput of that SCA to the NEGative INPUT of the 416A Gate and Delay Generator using the 0.61-m C-25-2 RG-58A/U 50-Ω cable.

b. Connect the UNIpolar output of the 575A Amplifier that supports the fixed detector to the INPUT of the 427A Delay Amplifier using a 0.61-m C-24-2 RG-62A/U 93-Ω cable.

c. Check that the OUTPUT of the 427A Delay Amplifier is still connected to the analog INPUT of the Easy-MCA, and the POSitive DELAYED OUTPUT of the 416A is still connected to the GATE input of the Easy-MCA.

d. Check that the amplitude and DELAY adjustments on the 427A and 416A still satisfy the pulse alignment conditions in steps 11, 12 and 13 of Experiment 19.1. If not, make the adjustments to satisfy those requirements.

e. Select the Coincidence Mode of operation for the Easy-MCA, and acquire a spectrum. The full ^{60}Co spectrum should be observed.

f. Select the WINdow mode on the 551 SCA. Adjust the LOWER LEVEL and WINDOW dials until the spectrum acquired by the Easy-MCA contains only the 1.17-MeV full-energy peak (or the 1.33-MeV peak, when repeating this step for the movable detector). Lock the dials to preserve this setting.

10. Repeat step 9 for the 551 SCA and 575A Amplifier serving the movable detector. But, set the SCA window to straddle the 1.33-MeV full-energy peak.

11. Set the DWELL knob on the 974 Counter-Timer to the OFF position to enable manual control of the stop/reset/count sequence. Set the value of N for the preset time to N = 3 to achieve a 100-second preset time. Reset the 974 Counter-Timer and initiate a preset counting interval. When counting stops note the number of counts recorded in counter 3.

12. Based on the result in step 11, calculate the preset time, t_{preset}, required to accumulate 10,000 counts in counter 3. Set the M and N preset time parameters to count for the chosen preset time. This ensures a 1% standard deviation for the recorded coincidence counts in counter 3. Check that this preset time will allow you to complete the subsequent measurements in the remaining time available for the experiment. If not, choose an appropriately shorter time. Record the choice of preset time.

13. Set the angle, θ, carefully at 180° (Fig 19.3). Accumulate counts for the preset time, t_{preset}. When the preset time limit is reached, record the counts in counters 2, 3 and 4 as N_2, N_3 and N_4, respectively. N_2 and N_4 are the counts for the gamma-rays in the movable and fixed detectors before the coincidence requirement is applied. N_3 represents the true coincidence counts plus the accidental coincidence counts. To determine the true coincidence rate a correction must be made for the number of accidental coincidence counts. Determine the accidental rate, N_{acc}, from the formula

$$N_{acc} = 2 \, \tau \, N_2 \, N_4 \qquad (3)$$

Where τ = 100 ns is the coincidence resolving time selected on the 414A Coincidence module. Consequently, the angular correlation value $w(\theta)$ is

$$w(\theta) = N_3 - N_{acc} \qquad (4)$$

14. Repeat the measurements in step 13 and determine $w(\theta)$ for the other angles listed in Table 19.1. It is a good practice to repeat the measurement at 90° several times during the course of the experiment to check proper alignment and repeatability of the system.

EXERCISES

a. In order to easily compare the experimental values with the theoretical values given by Eq. (1), it is more convenient to plot $G(\theta)$ vs. θ, where $G(\theta)$ is calculated by

$$G(\theta) = \frac{w(\theta)}{w(90°)} \qquad (5)$$

Plot the experimental $G(\theta)$ as a function of θ. Do the same for the theoretical $G(\theta)$ from the data in Table 19.1. Figure 19.7 shows a typical set of experimental and theoretical data for this experiment.

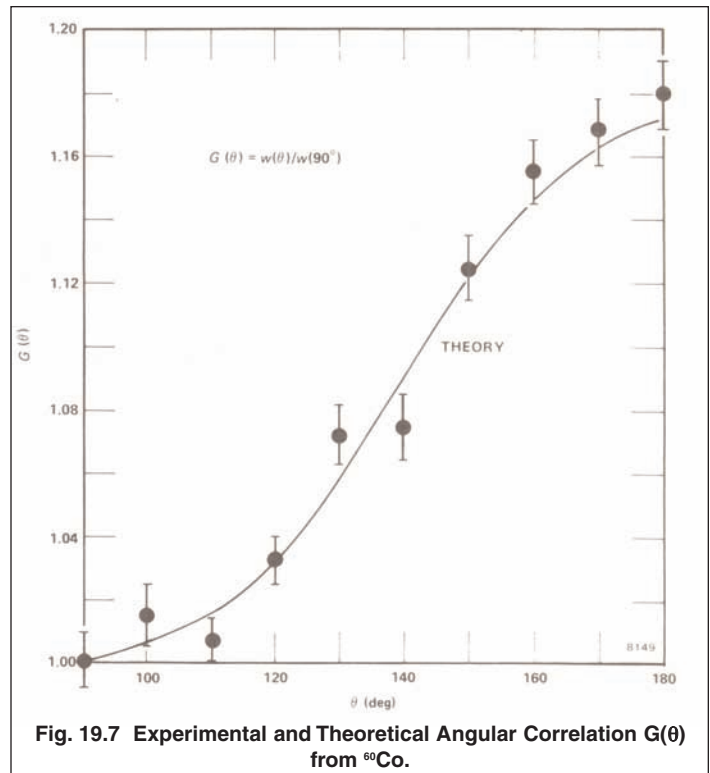b. Determine the anisotropy from the experimental data. How

Fig. 19.7 Experimental and Theoretical Angular Correlation G(θ) from ^{60}Co.

does this compare to the theoretical value?

c. Make a least-squares-fit to your data points and determine the experimental coefficients to the correlation function. How do your values compare with those in Eq. (1)?

References

1. A. C. Melissinos, *Experiments in Modern Physics*, Academic Press, New York (1966).

2. R. D. Evans, *The Atomic Nucleus*, McGraw-Hill, New York (1955).

3. H. A. Enge, *Introduction to Nuclear Physics*, Addison-Wesley, Massachusetts (1966).

4. C. M. Lederer and V. S. Shirley, Eds., *Table of Isotopes, 7th Edition*, John Wiley and Sons, Inc., New York (1978).

5. K. Siegbahn, Ed., *Alpha-, Beta-, and Gamma-Ray Spectroscopy*, North Holland Publishing Co., Amsterdam (1965).

6. P. Quittner, *Gamma Ray Spectroscopy*, Halsted Press, New York (1972).

7. W. Mann and S. Garfinkel, *Radioactivity and its Measurement*, Van Nostrand-Reinhold, New York (1966).

8. G. F. Knoll, *Radiation Detection and Measurement*, John Wiley and Sons, New York (1979).

ORTEC®

AN34 Experiment 19
A Study of the Decay Scheme
and Angular Correlation of ^{60}Co

9. J. B. Marion and F. C. Young, *Nuclear Reaction Analysis*, John Wiley and Sons, New York (1968).

10. Application notes, technical papers, and introductions to each product family at www.ortec-online.com.

Appendix: Apparatus Description

The Model 306 Angular Correlation Table pictured in Fig. 19.8 was originally manufactured by Metrix, and is no longer available from that source. The distances, R, indicated in Fig. 19.3 are 30.46 cm (12.0 inches). The lead shields in front of both detectors were made of 1.9-cm (0.75-in.) thick lead. The

Fig. 19.8 The Model 306 Angular Correlation Table Originally Manufactured by Metrix.

apertures in the lead shields were 2.54 cm (1 in.) in diameter, and centered on the cylindrical axis of each scintillation crystal. The angular settings were accurate to ±0.1°.

ORTEC®

www.ortec-online.com
Tel. (865) 482-4411 • Fax (865) 483-0396 • ortec.info@ametek.com
801 South Illinois Ave., Oak Ridge, TN 37831-0895 U.S.A.
For International Office Locations, Visit Our Website

AMETEK®
ADVANCED MEASUREMENT TECHNOLOGY