LABORATÓRIO DE FÍSICA EXPERIMENTAL AVANÇADA
Engª Física Tecnológica

MEDIÇÃO DA VIDA MÉDIA DO ESTADO NUCLEAR DE 14 keV DO ^{57}Fe

Pretende medir-se a vida média de um estado nuclear através da detecção de dois γ, em que γ_1 está relacionado com a criação desse estado e γ_2 com a sua extinção. Usa-se para tal um espectrómetro de 2 ramos que tem por base dois detectores de cintilação de NaI(Tl) (acoplados aos respectivos fotomultiplicadores) um com a usual blindagem de alumínio e outro (mais pequeno) com uma fina película de berílio* (de modo a permitir-lhe a detecção de radiação de poucos keV). Seguem-se os amplificadores de tensão, os analisadores monocanal, um TAC e um multicanal. Constituem ainda a montagem 2 geradores de alta tensão, com regulação a 900 V e a 710 V, respectivamente, e um *pulser*.

As partes que compõem o trabalho são as seguintes:

- Estudo do espectro de ^{57}Co : identificação dos seus picos com o auxílio da fonte conhecida de ^{137}Cs (pico fotoeléctrico de 662 keV e X_{Ba} de 32 keV).
- Medição do atraso relativo dos 2 ramos do espectrómetro usando uma fonte de ^{22}Na.
- Determinação da vida média do estado nuclear de 14 keV do ^{57}Fe :
  - ⋆ selecção, em cada ramo do espectrómetro, de um dos picos relevantes da fonte de ^{57}Co;
  - ⋆ obtenção da calibração temporal (Δt = f(canal)), com o auxílio do *pulser* e dos módulos de atraso (*delays*);
  - ⋆ longa aquisição nocturna de dados no multicanal (20 horas).

Segue-se o Guia detalhado do Trabalho.

Junta-se o Guia do TAC (*Time to Amplitude Converter*), cuja compreensão é essencial para a realização do trabalho.

* **ATENÇÃO: Tenha muito cuidado com este fotomultiplicador; não deve tocar-lhe, pois pode estragar a película envolvente do cristal**.

EXPERIMENT 13.3

Mean Lifetime Measurement of the 14 keV State in ^{57}Fe with Two NaI(Tℓ) Detectors and a Time-to-Amplitude Converter (TAC)

Discussion

Figure 13.7 shows a NaI(Tℓ) pulse height spectrum of a ^{57}Co source. Shown also on the figure is the decay scheme of ^{57}Co. Most of the decays (99.8%) are by electron capture (EC) to the 136 keV ($^5/_2^-$) state in ^{57}Fe. The 136 keV state can decay directly to the ground state or cascade with a 122 keV gamma to the 14 keV ($^3/_2^-$) state and then to the ground state. The 122 keV gamma is shown as γ_1 in the figure and the 14 keV group is γ_2. Figure 13.8 shows a high resolution germanium spectrum of this isotope with the 122 and 136 keV lines resolved. Figure 13.9 shows a high resolution Si(Li) spectrum of the ^{57}Co source. The strong Kα_1 and Kβ_1 lines are from (EC) and the 14.39 keV gamma from the ($^3/_2^-$) first excited state in ^{57}Fe are clearly seen in the spectrum. In this experiment we will use the 122 keV (γ_1) to start the TAC and the 14 keV (γ_2) to stop the timing sequence. Our data will thus yield the **Mean Life** τ_m of the 14.39 keV ($^3/_2^-$) level in ^{57}Fe.

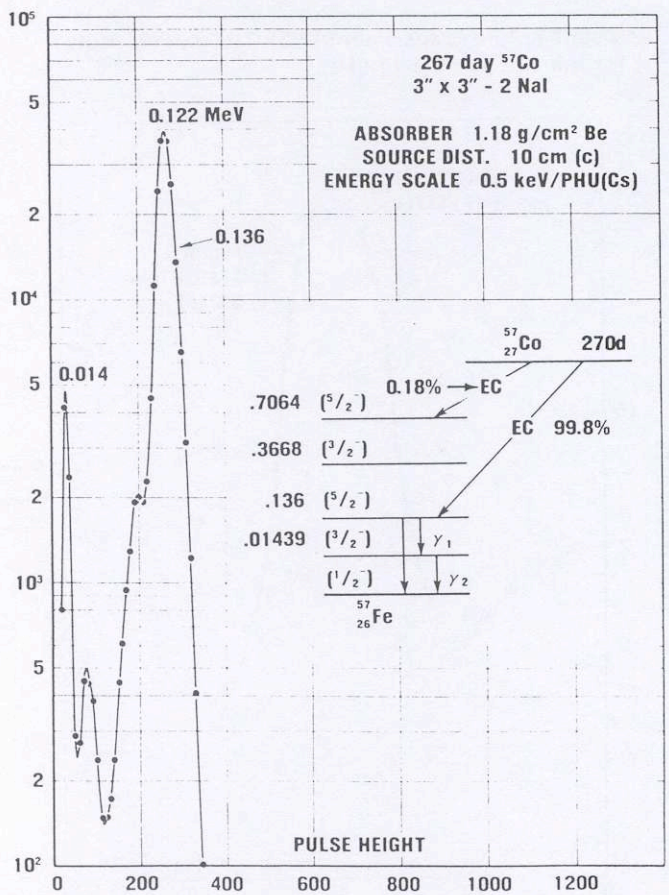


Figure 13.7. NaI(Tℓ) pulse height spectrum of a ^{57}Co source. Shown also on the figure is the decay scheme of ^{57}Co to levels in ^{57}Fe..

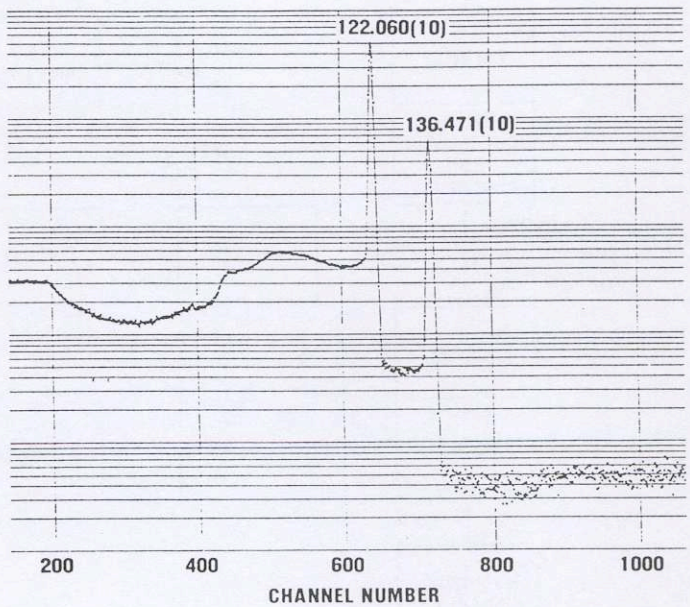


Figure 13.8. Germanium spectrum of ^{57}Co showing the resolved 136.471 and 122.060 lines.

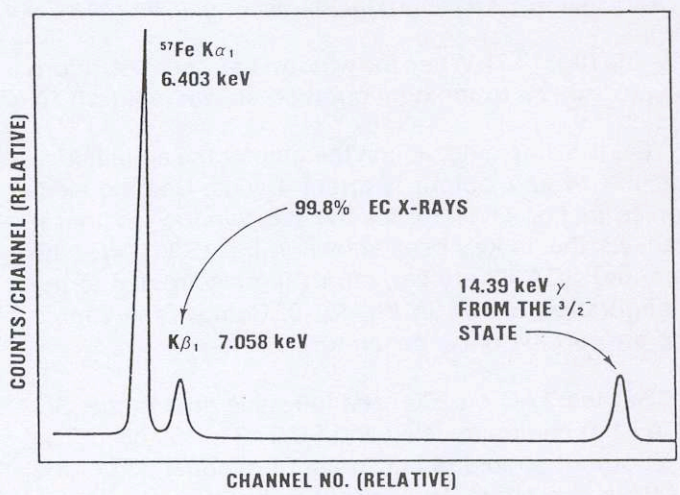


Figure 13.9. High resolution Si(Li) pulse height spectrum of a ^{57}Co source.

Experimental Procedure

1. Set up the electronics as shown in fig. 13.10. Set the high voltage supplies to their recommended values. Place the ^{57}Co source about 3 cm from each NaI(Tℓ) detector. **Note:** The TAC receives its start pulse from the top detector (γ_1). Adjust the gain of amplifier #1 so that the 122 keV gammas show an output of 4 volts. The output of amplifier #1, if fed into an MCA, should resemble fig. 13.7. Use the electronics schematic in fig. 11.11 to set the ΔE window of SCA #1 so that it brackets the 122

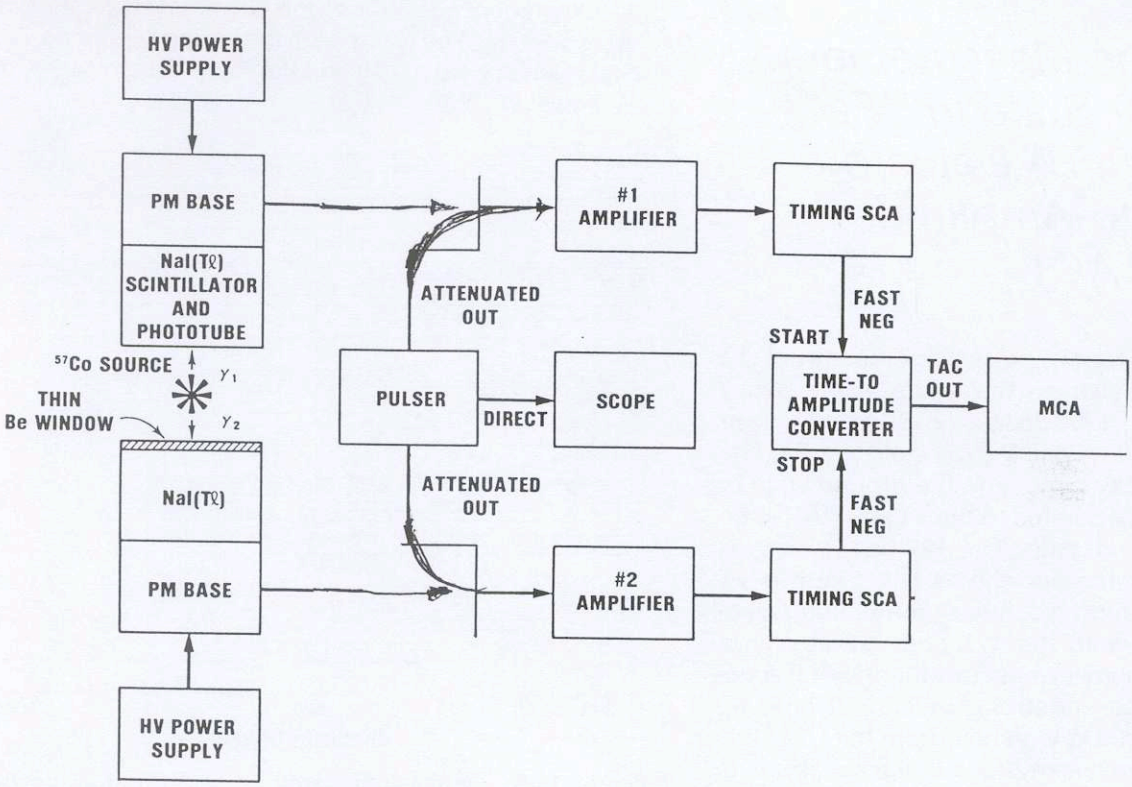


Figure 13.10. Electronics for measuring the mean life of the 14.39 keV state in ^{57}Fe (Experiment 13.3). The detectors used are a thin window NaI(Tℓ) for the 14 keV gamma and a 3" x 3" NaI(Tℓ) for the 122 keV start pulse.

keV line (fig. 13.7). When the window has been set, return the electronics to the configuration shown in fig. 13.10.

2. On the stop side, adjust the gain of the amplifier so that the 14 keV output is about 4 volts. Use the electronics in fig. 11.11 to set the ΔE window so that it brackets the 14 keV peak shown in fig. 13.11. After the gain and SCA #2 are set, return the electronics to the configuration shown in fig. 13.10. Remove the source and turn on the pulse generator.

3. Set the TAC on 200 nsec full scale time range. Set SCA #1 at minimum delay and SCA #2 at 150 nsec: The TAC output should occur in about channel 500 of the 1000 channel MCA. If it does not, adjust the delays in the SCA's so that it is stored about mid scale on the MCA.

4. Make a delay vs pulse height curve for the TAC. Plot the data and determine the time per channel for this 200 nsec range. Turn off the pulse generator and place the ^{57}Co source between the detectors.

5. Set the timer for a time of 600 sec and start the system counting.

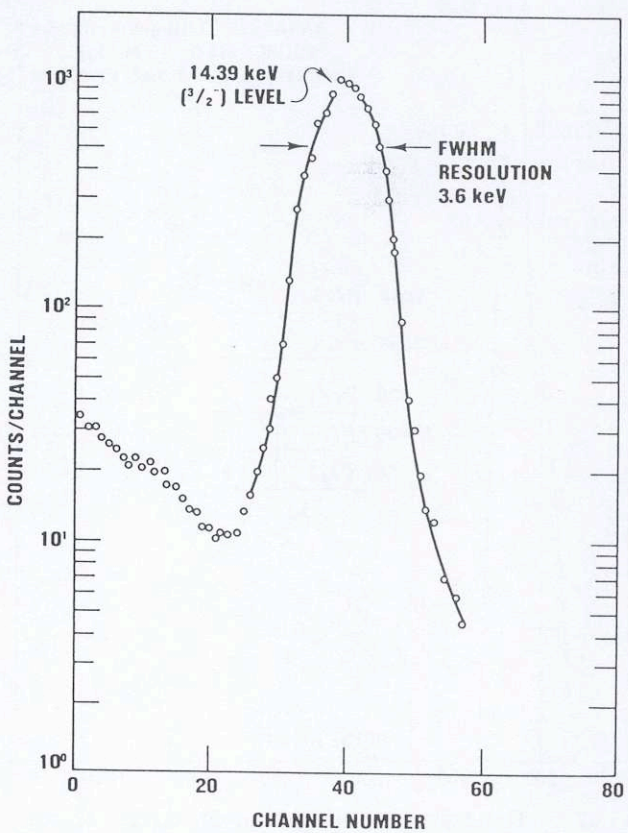


Figure 13.11. Beryllium window NaI(Tℓ) spectrum of the 14.39 keV gammas from a ^{57}Co source.

EG&G ORTEC MODEL 566 TIME-TO-AMPLITUDE CONVERTER

1. DESCRIPTION

1.1. PURPOSE AND FEATURES

The EG&G ORTEC 566 Time-to-Amplitude Converter (TAC) is a single-width NIM-standard module that measures the time interval between pulses to its start and stop inputs and generates an analog output pulse proportional to the measured time. Timing experiments requiring time ranges of 50 ns to 2 ms (10 ns to 2 ms usable time range) may be performed giving the experimenter flexibility in analyzing random nuclear events that occur within a selected time range. Time ranges from 50 ns to 2 ms are provided via the front panel controls.

The 566 Start input can be inhibited by a pulse or a dc level at the rear panel Gate In input connector.

Valid Start and Valid Conversion outputs are provided on the rear panel for each accepted start and stop input respectively. The duration of the Valid Start output indicates the interval from the accepted start until the end of reset. Valid Conversion occurs from the end of the internal delay after stop to the end of reset.

The selectable TAC output width and variable delay, which are easily adjustable, further serve to make the 566 a flexible instrument that can be easily adapted into many time spectroscopy systems. The output of the TAC may be synchronized with the stop signal or an external strobe signal to further enhance its versatility.

The 566 is dc-coupled and gated so that input count rates will not paralyze or otherwise hinder normal operation. The TAC output should be connected to the dc-coupled input of a multichannel analyzer (MCA) for optimum high-count-rate performance.

1.2. OPERATION

Start-to-stop time conversion is accomplished only after a valid start has been identified and after a stop pulse has arrived within the selected time range. The start input is disabled during the busy interval to prohibit pileup; the stop input is disabled after the first accepted stop signal. The input gate for the start circuit can be operated in either an anticoincidence or a coincidence mode.

Time ranges may be switch-selected for full-scale intervals from 50 ns to 2 ms. Each time measurement is analog-stored in a low-loss stretcher amplifier until a linear gate is opened by either an internal or an external strobe. The internal strobe can be obtained from either the start or the stop input pulse and in either case occurs automatically at a selected delay following the reference. An external strobe can be used for a prompt output at the strobe time provided that a time measurement has been completed and reset has not occurred. If reset occurs before a strobe, no TAC output signal is available. Reset also occurs if the start-to-stop time interval exceeds the range that is selected.

1.3. LOGIC

An input can be accepted through the Start input connector on the front panel unless the 566 is busy processing a previous set of information or the response is inhibited by a gate input condition. The acceptance of a start input is essential in order to initiate a response in the 566. When a start input is accepted, a positive logic signal is available through the rear panel Valid Start output connector and is continued until the leading edge of a subsequent reset. The reset can be caused by a TAC output or by the sensing of an overrange condition. The start signal permits the internal circuits to start measuring a time interval and enables the stop input circuit.

The Stop input BNC can accept an input signal after it has been enabled by the start condition. It may be enabled immediately after start. When a stop input signal is accepted, this indicates that an interval has been measured and its analog equivalent is stored and available. A signal is furnished through the Valid Converter output that continues until the leading edge of a subsequent reset. If no stop input is accepted before an overrange condition is sensed, the measurement will be aborted and no output signals for the TAC will be generated.

The TAC output must be strobed. The source of the strobe can be switch-selected from the internal signal or from an external signal. If internal is selected, the strobe occurs after a delay that has been adjusted with the front panel TAC Output delay control, 0.5 μs to 10.5 μs after the leading edge of the signal. If the Strobe switch is set at Ext, a signal must be furnished through the Strobe Ext BNC connector to strobe the output promptly.

2. SPECIFICATIONS

2.1. PERFORMANCE

TIME RESOLUTION FWHM ≤0.01% of full scale plus 5 ps for all ranges.

TEMPERATURE INSTABILITY ≤±0.01%/°C (±100 ppm/°C) of full scale or 10 ps/°C (whichever is greater), 0 to 50°C.

DIFFERENTIAL NONLINEARITY ≤±2% from 10 ns to 2% of full scale (whichever is greater) to 100% of full scale.

INTEGRAL NONLINEARITY ≤±0.1% from 10 ns to 2% of full scale (whichever is greater) to 100% of full scale.

RESET CYCLE Fixed 1.0 μs for X1 and X10 Multipliers; fixed 5 μs for X100 Multiplier; and fixed 50 μs for X1k and X10k Multipliers. Occurs after Overrange, Strobe cycle, or Ext Strobe Reset cycle.

START-TO-STOP CONVERSION TIME Minimum ≤5 ns.

2.2. FRONT PANEL CONTROLS

RANGE (ns) Three-position rotary switch selects full scale time interval of 50, 100, or 200 ns between accepted Start and Stop input signals.

MULTIPLIER Five-position rotary switch extends time range by a multiplying factor of 1, 10, 100, 1k, or 10k.

DELAY (μs) 20-turn screwdriver-adjustable potentiometer varies the delay of the TAC output from 0.5 μs to 10.5 μs, relative to an accepted Stop input signal; operable in the Int Strobe mode only.

STROBE MODE Two-position locking toggle switch selects either Internal or External source for initiating the strobe cycle to strobe valid information from the TAC output.

2.3. REAR PANEL CONTROLS

GATE MODE Two-position locking toggle switch selects Coincidence or Anticoincidence mode of operation for the Start circuitry. Start circuitry is enabled in the Coinc position or inhibited in the Anti position during the interval of a Gate input signal.

LOG CURR Two-position locking toggle switch selects the use of ±6 V or ±12 V bin lines to provide current for the internal logic circuitry. In the ±6 V position the 566 is within the current allotment for a single NIM width when using a NIM-standard Class V power supply. In the ±12 V position the 566 exceeds the current allotment for a single NIM width on the +12 V and −12 V bin lines. However, this position allows the 566 to be used with power supplies not providing +6 V and −6 V.

2.4. INPUTS

All four inputs listed below are dc-coupled, edge-triggered, and printed wiring board (PWB) jumper selectable to accept either negative or positive NIM-standard signals. Input impedance is 50 Ω in the negative position and >1 kΩ in the positive position. The threshold is ~=400 mV in the negative position and ~+2 V in the positive position.

STROBE Front panel BNC connector provides an external means to strobe a valid output signal from the TAC in the Ext Strobe mode. The input signal, exceeding threshold within the Ext Strobe reset interval after the Stop input, initiates the read cycle for the linear gate to the TAC output. Factory-set in the positive input position. Ext Strobe reset interval has a minimum value of ~0.5 μs and a maximum value of nominally 10 μs.

START Front panel BNC connector initiates time conversion when Start input signal exceeds threshold. Factory-set in negative input position.

STOP Front panel BNC connector terminates time conversion when Stop input signal exceeds threshold. Factory-set in negative input position.

GATE IN Rear panel BNC connector provides an external means of gating the Start circuitry in either Coincidence or Anticoincidence with the Start input signal. Gate input signal must cross threshold ≥10 ns prior to the Start input signal and must overlap the trigger edge of the Start input signal. Factory-set in the positive input position.

2.5. OUTPUTS

TAC OUTPUT Front panel BNC connector provides unipolar pulse.

Amplitude 0 V to +10 V proportional to Start/Stop input time difference.

Time End of delay period in Int Strobe mode; prompt with Strobe input in Ext Strobe mode.

Width Adjustable by PWB potentiometer from ≤1 μs to ≥3 μs.
Impedance $Z_o < 1\ \Omega$.
Rise Time ~250 ns.
Fall Time ~250 ns.

VAL ST Rear panel BNC connector provides NIM-standard slow-positive logic level signal.
Amplitude Nominally +5 V. Complement signal selectable by PWB jumper.
Time and Width From accepted Start input to end of reset.
Impedance $Z_o < 10\ \Omega$.
Rise Time ≤50 ns.
Fall Time ≤50 ns.

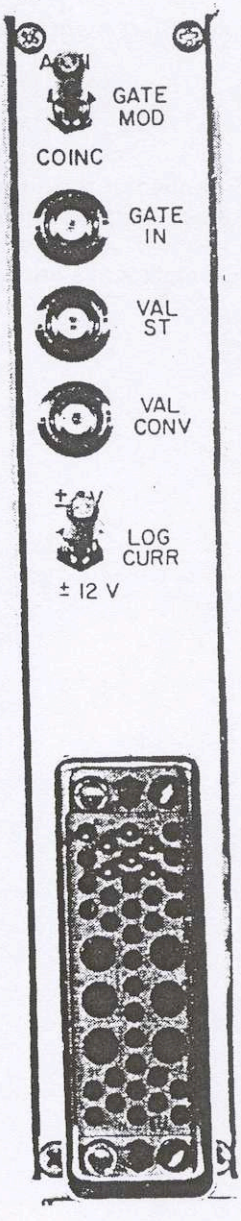
VAL CONV Rear panel BNC connector provides NIM-standard slow-positive logic level signal to indicate a Valid Conversion.
Amplitude Nominally +5 V. Complement signal selectable by PWB jumper.
Time and Width From end of internal delay after Stop to end of reset.
Impedance $Z_o < 1\ \Omega$.
Rise Time ~250 ns.
Fall Time ~250 ns.

2.6. ELECTRICAL AND MECHANICAL

POWER REQUIRED (Log Switch)
±6 V +24 V, 35 mA; −24 V, 50 mA; +12 V, 70 mA; −12 V, 105 mA; +6 V, 140 mA; −6 V, 300 mA.
±12 V +24 V, 35 mA; −24 V, 50 mA; +12 V, 210 mA; −12 V, 405 mA.

WEIGHT
Net 1.5 kg (3.3 lb).
Shipping 3.0 kg (7.0 lb).
DIMENSIONS NIM-standard single-width module 3.43 x 22.13 cm (1.35 x 8.714 in.) per TID-20893 (Rev).


ORTEC
566
TAC
RANGE(ns)
50
100
200
MULTIPLIER
10
100
1K
1
10K
DELAY (μs)
0.5
10.5
INT
STROBE
START
STOP
TAC OUTPUT


GATE
MOD
COINC
GATE
IN
VAL
ST
VAL
CONV
LOG
CURR
± 12 V