Lab Notes - Experiment VI, Nuclear Physics

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20/09/2024 - First Session

- Start of calibration using Cs-137

Upper right cable

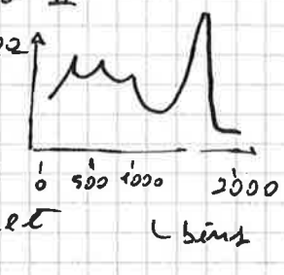
Using right detector → connected to right Amp

Right Amp : SCA to Pos Gate and Delay → Delayed out to Trigger (PC)

AMP to PHA-Input → Linear Delay → In

↓ Out to Multiport II

Peak obtained on the right with Coarse gain 50
Fine gain 2.5



Curve exported Logfile on the Quasi-Caution.

We want the bin corresponding to the peak to get on Energy value (using table for Cs-137)

File saved in Toolkit file format

Fit effectué (Scipy.optimize.curve_fit())

$\Rightarrow$ $A = 573.9 \pm 3$

$\mu = 1649.6 \pm 0.5$ $\Rightarrow$ Bin 16450 corresponds to 0.662 MeV

$\sigma = 86.2 \pm 0.5$

- Measurement : Pb-210

Data acquired

Additional measurement : 3.5, 3.7, 3.7, 3.8 s to get 1000 counts

- Measurement : Co-57

Data acquired

Add. meas. 1.2, 1.3, 1.3, 1.3 s to get 1000 counts

- Measurement : Na-22 (Remark : way slower activity!)

Aborted : low count, no spectrum obtainable in reasonable times 156.7, 156.3 s to get 1000 counts

- Measurement : Co-60

Aborted : low count : 209.9 s to get 1000 counts

One of the last 2 measurements will be taken again during Lunch break (to allow for longer times)

• Measurement : Hf-181

51.7, 55.9, 53.8, 49.3, 52.4 s to get 1000 counts

Data acquired

• Linear fit : $Y = E_\gamma$, x = channel

To get α, β, parameters of the linear relation between E_γ and the Voltage (Amplitude of the signal)

Hafnium gives unexpected curve (should see two curves at low energy, only one visible).

• Measurement : Hf-181 2nd time

Abort All

Redoing all measures for higher upper Energy limit.

Target : Cs at channel ~ 750 (γ_1, 0.662 MeV)

AND Co-57 must be clearly visible (γ_2, γ_1)

• Measurement : Cs-137

0.3, 0.3, 0.3, 0.3 s to get 1000 counts

Data acquired → Curve compatible with previous measure

• Measurement : Co-57

Curve and counts compatible with previous measure

Data acquired

• Measurement : Pb-210

Counts differ from previous measure

11.2, 11.9, 11.0, 11.1, 12.2 s for 1000 counts

Data acquired

• Measurement : Na-22

Data acquired → inconclusive (peak doesn't show).

← Matin / Après-midi

• Start of attenuation study (Using Cs-137)

↓ Peak was isolated

1) Aluminium

→ ~~4.878 mm + 0m cst~~

Set up 25 cm between source and detector

Too much! Effective collimation but very long measure times

Set up 15 cm "

Measures taken with 1,2

Thickness pellets [mm] : 5.078, 5.084, 5.078, 5.0??, 5.152

Obtained attenuation coefficient ~ + 0.02 mm^{-1}

1% Relative error for event count

2) Lead

Thickness [mm]: 5.008, 5.048, 5.050, 5.102

Obtaine attenuation coefficien ~ 0.[illegible]1 mm^{-1}

- Statistique - Low mean

Program Comma - MCS_NAI

Dwell value of 10.0 ms → Civet mean of 7.65

Already quite similar to Caussian.

⇒ Lowered value (Dwell value)

Dwell value of 3 ms → Mean 2.27

- High mean

Dwell value 1 s → Too long

0.3 s → Data acquired

Need to perform χ^2 tests (with respect to Caussian and Poisson) on both low and high mean results.

- Back to Gamma Spectrum

Hofmann measurement

→ Peak identified ⇒ 4th point added to calibration

27/03/2024 - Second session

8:28 Start of work → • Coincidence preparation (Cs-137)

Setup check, previous calibration check

Correctly calibrated. Coincidence wiring

Set window to only see γ_1 peak

Checking counts for 1, 2 and coincidence

$m_1 \sim 4m_2$? Problem

Problem found: Source needs to be vertical in order to have simmetry.

Det. (thin) Source Det. (Stand.)

[1] * [2]

Source placed vertically in the approximate middle to get similar counts on both detectors (≤ 5% difference)

Finding resolution 2θ (using Cs 137)

- measure counts for each detector + coincidence
- ~~Abridger~~ Vary measurement time to obtain linear relation $m_{12} = 2\theta\, m_1 m_2$

$t = 100s,\ 50s,\ 20s,\ 10s,\ 70s \quad \pm 0.1\ s$

Data is very noisy, try measuring until 4000 coincidences

Probable error in the analysis code. Must check

Halt 2θ measurement. Need to try with 2 sources but only 1 available.

• Start of Cobalt-57 study.

Left detector → window restricted to γ_2 peak

↳ Coinc: 50 + 1, window 0.~~3~~2, Lower level 0.20

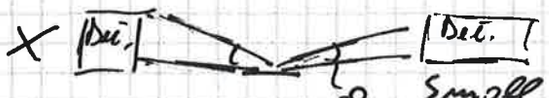
Adjusted to window 0.40, Lower 0.16

Zero coincidence counts. Setup doesn't work.

Problem found! Wrong geometry:

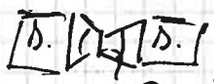
366.8 kBeq activity of the source in 2018!

~?



Small solid angle → Low counts

Right before ← Coinc changed



Big solid angle → High counts

Obtained first approximate value of $A_{Co\text{-}57} = 4126$ Bq

Values used on Amp: Left: C = 500 + 1, window 2.12, Lower 2.50

Right: C = 20 + 2.5, Window 0.30 Lower 0.28

• Back to determination of 2θ

Two ^{137}Cs sources now.

Measurements with ~10.000 coincidences.

Results compatible with previous measurements

Good numerical values but the datapoints are not aligned with each other on the plot.

Tried lowering # of coincidences to check for clusters of datapoints. Also distanced the two detectors a bit more

Figured out the problem: need to try asymmetrical values of m_1 and m_2
⇒ Perfect linear relation
Final result $2\theta \approx (2.04 \pm 0.01) \cdot 10^{-6}$

- Cobalt-57 Spectrum

Source: 366.8 kBq, 01.09.2018
Windows adjusted: Left detector → γ_1 peak: W 2.54, L 2.34
Right detector → $\gamma_{2,3}$ peak: W 0.36, L 0.48

Window doesn't work when triggering with left and measuring with right.
Measure started.

04/10/2024 - Third session

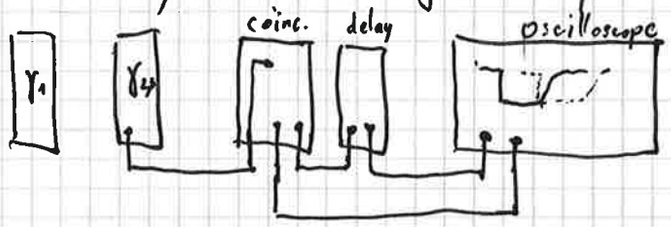
- End of ^{57}Co γ spectrum data acquisition.
Steps necessary for data analysis:
  → normalise calibration spectrum
  → apply some normalisation to acquired spectrum
  → multiply acq. by 88%
  → substract the two

- Start of TAC calibration

  → Check windows for correct peaks
    ↳ ⚠ Problem: switch put on "interval" and not "window" so window adjustment didn't work
    ↳ $\gamma_{2,3}$ ✓
    ↳ γ_1: put ~~delay~~ delay in middle, 11 µs
    Check with previous spectrum, bin should be at ~600 ✓

9:00 Windows are correct

Check delay between signals (split from $\gamma_{2,3}$ peak) on oscilloscope



use negative for input to TAC

10:00 Weird drifting issue with TAC on higher delays

↳ try making all cables the same length (0 delay ≡ simultaneous)

10:38 Still troubleshooting

13:11 Problem solved — Time range and multiplier gave problems

There is a certain window of values which do not cause drifting

13:15 Calibration complete

Bin x corresponds to $(5.93 \pm 0.06) \times 10^{-4} x + (7.5 \pm 0.5) \times 10^{-1}$ μseconds

13:54 Problem with window selection

15:00 Drifting problem persists, tried:

- restart whole setup
- rewire from scratch with same-length cables
- count events while measuring / calibrating delay
- de couple / unplug cables to osciloscope
- tried another TAC
- use other digital delay generators

Randomly, drifting stops for a few measurements of elapsed time (~250) then starts again after looking too much at the measurement chain (QM?)

15:45 Calibration quickly redone, drifting non-negligible 980 ns, associated to bin 454 + shift between the signals

11/10/2024 - Session 4

- Half-life measure not recorded Monday (bad wiring)

Decay curve obtained → Data analysis

Problems with fitting the obtained curve

Calibration still valid! Checked with one source split in two outputs (930 ns where previously 970 ns ✓)

Data fitted → $t_{1/2} \approx 0.123$ μs

Normalisation doesn't work because not whole spectrum

Uncertainty to be estim (Dittert: "systematic study not possible in the time window of the experim.")

- Restoreting γ_{213} subtraction measure
Checking windows (remember to put MCA in coincidence mode!)
Coincidence wiring.
Preliminary (~2 hours of measure) results give good values.

Measure will run until Monday