ANGULAR CORRELATION IN Ni^{60}

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1. INTRODUCTION

The Ni^{60} angular correlation experiment has been performed at this institute for training purposes.

Fig. 1 shows the decay sheme of Ni^{60}.

The theoretically expected correlation function between the two gamma-rays is:

$$W(\theta)= 1 + \left(\frac{1}{8}\right) \cos^2 \theta + \left(\frac{1}{24}\right) \cos^4 \theta$$

2. APPARATUS

The experimental arrangement is shown in fig. 2, and the block diagram of the electronics in fig. 3. The coincidence resolution time is $0.75.10^{-7}$ sec. For detailed electronics see Appendix I. The Co^{60} point source of about 17 curies was movable in horizontal directions, which made a centering up to 3% possible(Appendix III).

3. CHECKS

a) The elctronics reproducibility was determined by repeated countings of singles and coincidences at diffeent hours, without changing the experimental situation. Clear dependences of the counting rates on the room temperature and the main voltage (Appendix II) were eliminated by stabilizing both room temperature and voltage.

b) The mechanical reproducibility was checked by measurements before and after having moved the detector (Appendix III).

c) For other checks on the electronics (linearity of pulse height analysers etc.) see Appendix I.

4. MEASUREMENTS AND RESULTS

The spectra as determined with both analysers (in the actual experiment used only as discriminators) are shown in fig. 4 where also the finally chosen bias settings are indicated. The bias curve by the fast coincidence, with the bias setting chosen is shown in fig. 5.

The coincidence resolution time ($0.75.10^{-7}$ sec.) and the accidental ratio ($\frac{1}{15}$) were measured by introducing variable delays in the single channels (see fig. 6). The given values are in agreement with the relation:

$$\frac{N_{acc}}{N_{true}} = 2\ N\ \text{source and}\ N_{acc} = 2\ N_1 N_2.$$

The results of the angular correlation measurements are given in fig. 7. The drawn curve is a fit to the measured points and the dotted one represents the theoretical function.

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The pulses coming from the cathode followers are at the same time fed to the linear amplifiers and pulse height analysers, both set to the discriminator position at the selected energy level.

The linearity of all circuits from the crystal up to analysers was checked with several radioactive samples and found to be within the accuracy of the analysers utilized.

As the delay in the analysers is not the same, and is somewhat dependable on the bias setting, and the fast coincidence bias is about zero, we should have put two or three delays before slow triple coincidences, to make the three pulses originates in a coincidence arrive there at the same time. But some computations showed us that the triple slow coincidence may have a resolution time as large as 20 microseconds. Therefore, instead of putting delays, we used three pulse forming circuits, composed of one multivibrator each one, with a pulse width of 20 microseconds. From those multivibrators the coincidence is made directly, in the plate circuits, where a 50 volts square positive pulse appears, with three germanium diodes.

The triple slow coincidence is followed by a discriminating multivibrator and a tube that receives the stopping signal.

The scalers are one Ekco Automatic Scaler with Dekatron tubes, one Philips scaler, and a home built scaler, both with E1T tubes, the last preceeded by a fast scale of ten dividing network.

The stopping signal is made with a negative pulse that exists in the Ekco automatic scaler.

The high voltage is supplied with an Ekco Power Unit, and the other voltages with a common power supply, capable of delivering stabilized outputs of 250 and -150 volts.

APPENDIX I- DETAILED ELECTRONICS

The circuit, according to the block diagram, is a fast+ slow coincidence arrangement (fig. 3).

The cathode followers utilized are of the conventional type, utilizing one EL84 tube in triode connection. The output is matched to the line or 135 ohms characteristic impedance, with a 47 ohms resistor. In such a way, we eliminate reflections in the input end of the line. The shielding of the input cable is connected to the cathode, and the grid is returned to a point of the cathode resistor, in order to reduce as much as possible the input impedance, that is of the order of 10 megohms and 3 picofarads (fig. 8,9).

The fast amplifiers are composed of three EF95 tubes, the first two being conventional amplifiers, and the third is the circuit developed by Bell and Petch for fast coincidences with slow scintillators(fig. 10). The delay is introduced when necessary in the plate circuit of the second stage, and is composed of HH-2000 delay cable, which is then matched at both ends with the two 2K2 resistors.

The third stage acts as a limiter, the grid being driven enough negative as to cutoff the plate current, so that the plate signal has a definite maximum amplitude. This pulse in the plate is clipped with a short + circuited line of the helicoidal type, of 1,000 ohms characteristic impedance (fig.11). The lenght of the clipped pulse is about 0.15 microseconds, and its amplitude may be as large as 4 volts, positive. The rise-time of the amplifier was calculated in about 8×10^{-8} sec, which is enough for the actual purposes.

The clipped positive pulses are fed to a diode coincidence circuit. This circuit is mounted carefully, to avoid stray capacitances, using short connections. The values of the resistors of the voltage divider for the coincidence are such as to give the circuit the ability to follow the coincident pulses at the same rate of rise.

The coincidence is followed by a diode stretcher, that stretches the narrow pulse of 0.15 microseconds to about 20 microseconds; this pulse is then stretched and fed to a dicriminator circuit. As a paralel capacity of the discriminating diode introduced serious prohlems for biasing all the pulses, we preceeded it with a cathode follower that allowed us to use low valued resistors in both sides of the diode; in this way we overcome the shunt capacity problem. The output of the discriminator (fig. 12) is fed to one more amplifying stage, and then to a pulse forming cir-

APPENDIX II

ELECTRONICAL REPRODUCIBILITY

Many counts have been done with invariant conditions of geometrical arrangement (see fig. 14).

The temperature and Mains voltage variation were measured.

It was expected a constancy of the counts. This didn't happen and the analysis of the curve of single counts, temperature variation and main voltage showed a correlation between these three parameters.

The conclusion was that the temperature variation changed the crystal efficiency in a non negligible way, as reported by many authors 1.

An experiment was done: the temperature in the crystal region was raised from 14º to 40º C. This 26º variation originated 40% single counts variation.

After this, an air conditioning system and a mains voltage stabilizer have been used. So the temperature variation was reduced to 2ºC (This temperature measured by a thermometer near the crystal).

A great number of measurements has been done showing an electronical reproducibility of 3% (see fig. 15).

BIBL.: 1– R.D. Connor and M.K. Husain, Nuclear Instruments 6 (1960) 337

APPENDIX III

MECHANICAL REPRODUCIBILITY AND CENTERING OF THE SOURCE

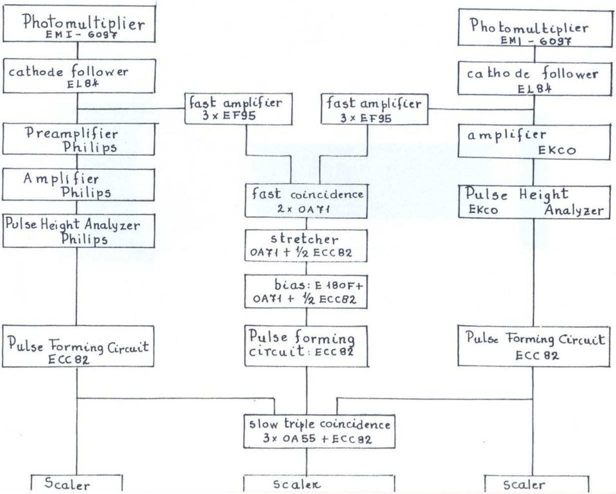
The mechanical reproducibility (fig. 16) has been checked by measuring the simple counts in a definite position of the detector them turning it to another position and setting it back to the first position. This procedure has been performed for three different positions and the result was an accuracy of 1,5% in the mechanical reproducibility. Care has been taken in order to avoid any other pertubation in the whole system; also the source has not been moved during the whole experiment.

Once the mechanical reproducibility was assured, the source has been centered (fig. 17) in the usual way [2] at 3%.

To correct in first order the error due to the assimetry in the centering of the source the coincidence counts have been normalized. This normalization was done by multiplying the average single counts and dividing by the product of the single counts measured [3].

BIBL.: 2- H.Frauenfelder, in Beta-and Gamma-Ray-Spectroscopy, Ed. K.Siegbahn (North-Holland Publishing Co., Amsterdam 1955 Ch. XIX) .
3- E.L. Brady and M. Deutsch, Phys. Rev., 78,558 (1950).

2 - COMPLETE BLOCK DIAGRAM



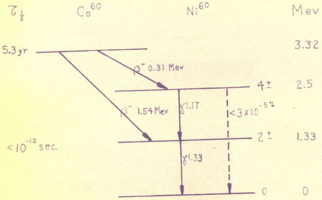


FIG. I - Decay Scheme of Ni^{60}

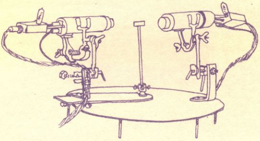
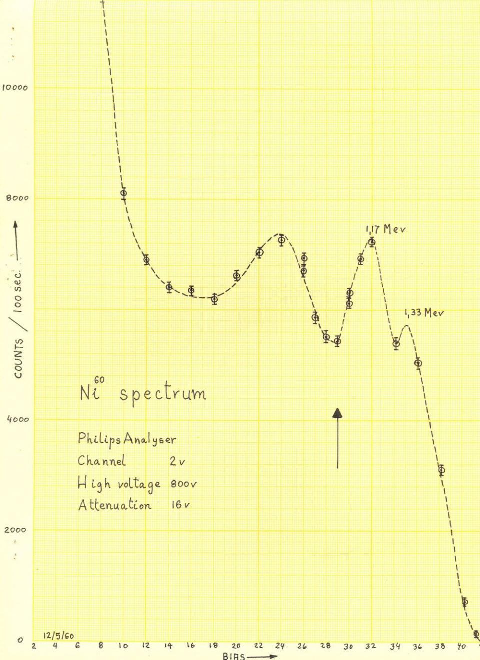


FIG. 2 - Experimental Arrangement



10000
8000
4000
2000
0
COUNTS / 100 sec.
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
BIAS
1.17 Mev
1.33 Mev
Ni 60 spectrum
Philips Analyser
Channel 2v
High voltage 800v
Attenuation 16v
12/5/60