**EXPERIMENT. Counting Statistics**

**Purpose**

As is well known, each measurement made for a radioactive sample is independent of all previous measurements, because radioactive decay is a random process. Repeated individual measurements of the activity vary randomly. However, for an ensemble comprising a large number of repeated, individual measurements, the deviation of the individual counts from what might be termed the "ensemble average count" behaves in a predictable manner. Small deviations from the average are much more likely than large deviations. In this experiment, we will see that the frequency of occurrence of a particular deviation from this average, within a given size interval, can be determined with a certain degree of confidence. Fifty independent measurements will be made, and some rather simple statistical treatments of the data will be performed. The experiment utilizes a 60Co source which has a half-life that is very long compared to the measurement time. The 5.26-year half-life ensures that the activity can be considered constant for the duration of the experiment.

**Relevant Equations**

The average count for n independent measurements is given by

where N1, N2, N3, …… Nn and Ni are the counts in the n independent measurements.

The deviation of an individual count from the mean is (Ni – Nav). Based on the definition of Nav



For cases where the percent dead time losses are small, it can be shown that the expected standard deviation, σN, can be estimated from



with the estimate from Nav being more precise than the estimate from the individual measurement Ni. See references 10 and 11 for details. Thus, σN is the estimate of the standard deviation expected for the distribution of the measured counts, Ni, around the true mean.

Frequently, one is dealing with counting rates, rather than counts. If the true counting rate is defined by the number of counts accumulated in the counting time T, i.e.,



then, the estimated standard deviation in the counting rate can be calculated from



A meaningful way to express the statistical precision of the measurement is via the percent standard deviation, which is defined by



Note that achieving a 1% standard deviation requires 10,000 counts.

**Procedure**

1. Set the operating voltage of the detector at the value determined previously

2. Place the 60Co source far enough away from the detector so that ~ 1000 counts can be obtained in a time period of 0.5 min.

3. Without moving the source, take 50 independent 0.5 minute runs and record the counts for each run in Table 2.2. (Note that you will have to extend Table 2.2; only ten entries are illustrated.) The counter values, Ni, may be recorded directly in the table since, for this experiment, Ni is defined as the number of counts recorded for a 0.5 minute time interval.

4. With a calculator determine Nav from Equation (21). Fill in the values of Ni – Nav in Table 2.2. It should be noted that these values can be either positive or negative. You should indicate the sign in the data entered in the table.

**EXERCISES**

a. Calculate σN, and fill in the values for σN and (Ni – Nav)/σN in the table, using only two **decimal places**. Next, round off the values for (Ni – Nav)/σN to the nearest **0.5** and record the values in the “Rounded Off” column of the table. Note that in Table 2.2 we have shown some typical values of (Ni – Nav)/σN and the rounded-off values for guidance.



b. Make a plot of the frequency of the rounded-off events (Ni -Nav)/σN vs. the rounded-off values. Fig. 2.3 shows this plot for an ideal case. Note that at zero there are eight events, etc. This means that in our complete rounded-off data in Table 2.2 there were eight zeros. Likewise, there were seven values of +0.5, etc.

c. Does your plot follow a normal distribution similar to that in Fig. 2.3?

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