DETERMINATION OF SYSTEM DEAD TIME

Introduction:

The purpose of this part of the experiment is to demonstrate methods for determining system dead time and the practise of handling radioactive liquids. The stock solution has the nominal activity of 4 MBq ml\(^{-1}\) with a 15 hour half-life. **ALL PROCEDURES MUST THEREFORE BE PERFORMED WITH EXTREME CAUTION!**

Procedure:

**Part I. Sample preparation**
The stock solution (\(^{24}\)NaNO\(_3\) in water) occupies a volume of 1.1 ml and is used to prepare a series of samples of known relative activity. This is done volumetrically.

Samples are prepared by dispensing and evaporating 50 \(\mu\)l aliquots onto aluminum planchets. The planchets have corrugated concentric rings which are used in the evaporation of large volumes to prevent deposition of the entire sample at the periphery. In this experiment the central section matches the aliquot area.

Make six samples using the pipette with disposable tip. Before using this instrument, practice how to operate with the instructor or a TA. Always transfer the liquid very slowly. Gently depress the plunger to the first position only before inserting the tip into the liquid. When dispensing the sample, try to keep the pipette tip in contact with the expelled liquid until the transfer is complete.

**#1**: 1 aliquot, **#2**: 2 aliquots, …, **#5**: 5 aliquots
**#6**: Sample 1 aliquot of the stock solution and then add it to a 1 ml of distilled water.
Shake the mixture gently and then using a fresh tip, sample 1 aliquot.

Evaporate all samples with the heat lamp.

**Part II. Observe signal pulses**
Set up the high voltage & counting unit so that you can observe the signal as you did in the Lab 1. **MAKE SURE THE HIGH VOLTAGE IS OFF WHILE CONNECTING AND DISCONNECTING CABLES!**

After evaporation, place a sample in one of five tray positions.

Observe the detector pulses and record the length of the gap between the pulses which begin the scope sweep, and those appearing during the sweep for each sample. For each sample tray position, record the length of the gap between the pulses.
Part III. Counting
Get the high voltage & counting unit back to the counting mode. **MAKE SURE THE HIGH VOLTAGE IS OFF WHILE CONNECTING AND DISCONNECTING CABLES!**
Count a sample for a suitable period in each of the 5 tray positions.
Count the other samples.

Data analysis:

1. For convenience, the true counting rate $C_{ni}$ for each sample is represented as $C_{n1}x$, where $C_{n1}$ stands for the true interaction rate of the “sample 1”. For each tray data set, plot $1/C_{mi}$ as a function of $1/x$, where $C_{mi}$ is the measured counting rate. Fit each data set with a straight line. Determine the dead time and $C_{n1}$ from the non-paralyzable model. Discuss the consistency of the dead time from each set.

2. For each tray data set, plot $ln(C_{mi}/x)$ as a function of $x$ and fit each data set with a straight line. Determine the dead time and $C_{n1}$ from the paralyzable model. Compare the dead time from the paralyzable model with the dead time from the non-paralyzable model. Also compare the dead times with the oscilloscope observations.

3. If the stock solution was prepared from 40 mg of $^{24}$NaNO₃ dissolved in 1 ml of H₂O, estimate the source thickness (mg cm⁻²) for the most active sample.

4. Look up the decay properties of $^{24}$Na. Comment on the source thickness and the beta decay energy.

5. Calculate the dead time correction factor for the diluted source at each tray position. Is it reasonable to assume that the measured counting rate is almost same with the true counting rate for the diluted source?

**REFERENCES**

Medical Physics 4R06/6R03 Lecture Note, Chapter 2.