Advanced Laboratory II

Experiment 3: Half-Life Measurement of Neutron Activated Aluminum

In this experiment you use the NaI (Tl) scintillator detector to measure the half-lives $T_{1/2}$ of 3 radioactive isotopes which were produced by neutron activation of aluminum. The activation happens on the day of the experiment using a strong laboratory neutron source at Mines and involves the following nuclear reactions:

Notation: $X(a,b)Y$ Reaction Target (Projectile, Light Ejectile) Reaction Product

1) $^{27}\text{Al}(n,\gamma)^{28}\text{Al}$ $T_{1/2} = 2.25$ m

2) $^{27}\text{Al}(n,p)^{27}\text{Mg}$ $T_{1/2} = 9.45$ m

3) $^{27}\text{Al}(n,\alpha)^{24}\text{Na}$ $T_{1/2} = 14.95$ h

As a first step of your work you should figure out what gamma photon energies you can expect to see from your reaction products. Then you should calibrate your detector very carefully using the $^{137}\text{Cs}$, $^{60}\text{Co}$ and $^{22}\text{Na}$ sources. In order to extend your calibration range to higher energies, I recommend also to take a background spectrum and include the $^{40}\text{K}$ and high energy $^{208}\text{Tl}$ lines in your calibration.

As the measurement of a half-life will need the repeated measurement of a sample in given time intervals, we will use a feature of MAESTRO where we operate a start/stop/save/erase cycle via external script. I recommend testing the operation using a long half-life source from our inventory.

A first set of the activated samples will be delivered to you when all groups are ready with their setup tests. These samples were activated for several days and will therefore exhibit activity from all three isotopes. A first set of MAESTRO script measurements should focus on the $T_{1/2}$ of $^{27}\text{Mg}$ with a run of 15 x 2 minutes measurements. This set should over lunch be followed with a run of 6 x 15 minutes focusing on the $^{24}\text{Na}$ activity.

A second set of activated samples, activated over only app. 2 hours, will exhibit predominantly the activities from $^{28}\text{Al}$ and $^{27}\text{Mg}$. A run of 30 x 1 minute is recommended for this experiment.

Please perform online analysis, there will be time for another activation if your first sets fail.