EKA Advanced Physics Laboratory

# Gamma Ray Spectrometer Experiment

Getting Started Guide

In this experiment you will be using a NaI scintillation counter to study the spectra of gamma rays emitted by radioactive nuclei. The purpose of this document is not to explain the experimental procedure or the physics involved, but to provide a step-by-step guide to get started with the equipment, which is pictured in Figures 1 and 2:

***Figure 1:*** *NaI scintillation counter, surrounded by radiation shielding blocks. The small black box behind the photodetector is the multi-channel analyzer (MCA) which interfaces with the computer. In the background are the high-voltage power supply (see Figure 2) and the computer.*


***Figure 2****: The power supply unit (L), signal amplifier (C) and high-voltage supply (R).*

All the equipment should be wired up and only needs to be powered on; if there are any problems with the connections please see an instructor.

1. *To get started, let's turn on the power to the high-voltage power supply.*
    - The **main power switch** is on the rear of the unit marked "Portable Bin/Power Supply." Switch it on.
    - The **high voltage switch** is on the lower right of the high voltage supply, below the knobs and dials. Turn it on.
    - Next, set the **high voltage** to 1200V. To do this, turn the knob to 1000V, and set the digital dial to 200; the actual voltage is the sum of the two readings.
    - This is the high voltage that supplies the phototube. **CAUTION:** ***It is critical that the voltage not exceed ~1200V to avoid damaging the tube***, but it must be set at or near 1200 in order to record counts.
    - Finally, set the **amplifier gain** to 100. This is the middle knob, just to the left of the high-voltage knob. This adjusts the scaling of gamma ray energy to the signal produced, to have greater sensitivity in different spectral ranges. A setting of 100 will do for now.

At this point the phototube is powered up and ready to go.

2. *In order to hook up the computer, follow this procedure:*
    - Turn on the **MCA power**. This is a small red button on the black MCA unit. When you press it a small red light should come on and it should make a high-pitched noise.
    - Power on the computer. On the desktop will be an icon for the PMCA program, which interfaces with the MCA unit. From the menus at top, select **MCA => Connect**, which will connect the computer to the MCA unit.

We are now ready to begin. To get started let's look at the sample container (the radioactive sources are located in a locked storage room; have a lab instructor retrieve the samples).

***Figure 3:*** *Sample container. The actual samples are in the black/colored piece at the ends; the remainder is a clear plastic handle by which to handle the sample.*

3. *Inserting a radioactive source*

To start, let's choose the Cs-137 sample. Remove it from the box by the clear plastic handle, and place it next to the phototube as pictured in Figure 4. Make sure the sample faces towards the detector, and try to center it on the detector's face. It is unnecessary to press the sample against the detector; just position it next to the detector's face. Also arrange the shielding to prevent unnecessary exposure. While these samples are relatively weak, it always makes sense to minimize exposure anyway.

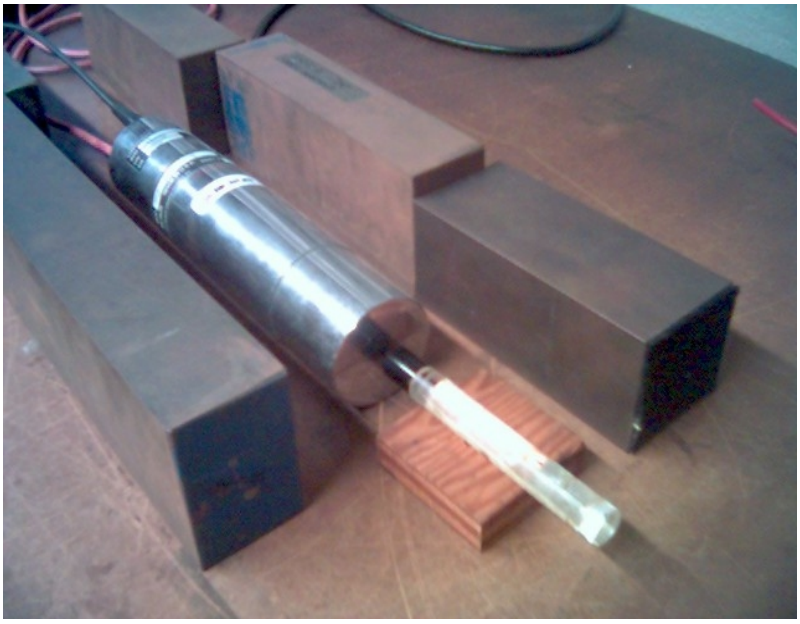

***Figure 4:*** *Correct sample alignment*

*4. Viewing the output on the oscilloscope*

To see what the source's gamma ray spectrum looks like, power on the oscilloscope, which is connected to the amplifier output, using the power button at lower left. You should see the following (after adjusting scales as necessary):

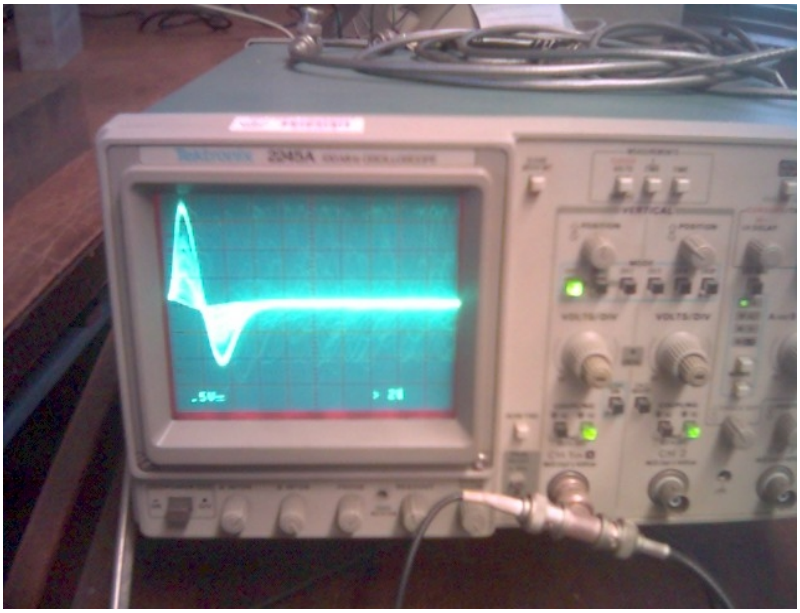

***Figure 5:*** *Oscilloscope output from Cs-137 source*

The "sine wave" that you see at left is the signal produced by the amplifier, with its amplitude proportional to the detected energy. The maximum-amplitude signal is the **photopeak,** due to complete absorption of the gamma ray by the detector; the weaker signals at lower amplitude correspond to partial absorption of the gamma ray energy by the detector (i.e. Compton scattering rather than absorption). We will see this spectrum in more detail using the computer.

This is the "raw" gamma ray spectrum. After using the computer to see the spectrum you should be able to come back to the oscilloscope and identify the main spectral features here as well.

*5. Using the PMCA software*

To begin data acquisition, Select **MCA -> Start Acquisition** from the software's menu bar. Counts will begin

accumulating and a plot will appear on screen, similar to Figure 6 below:

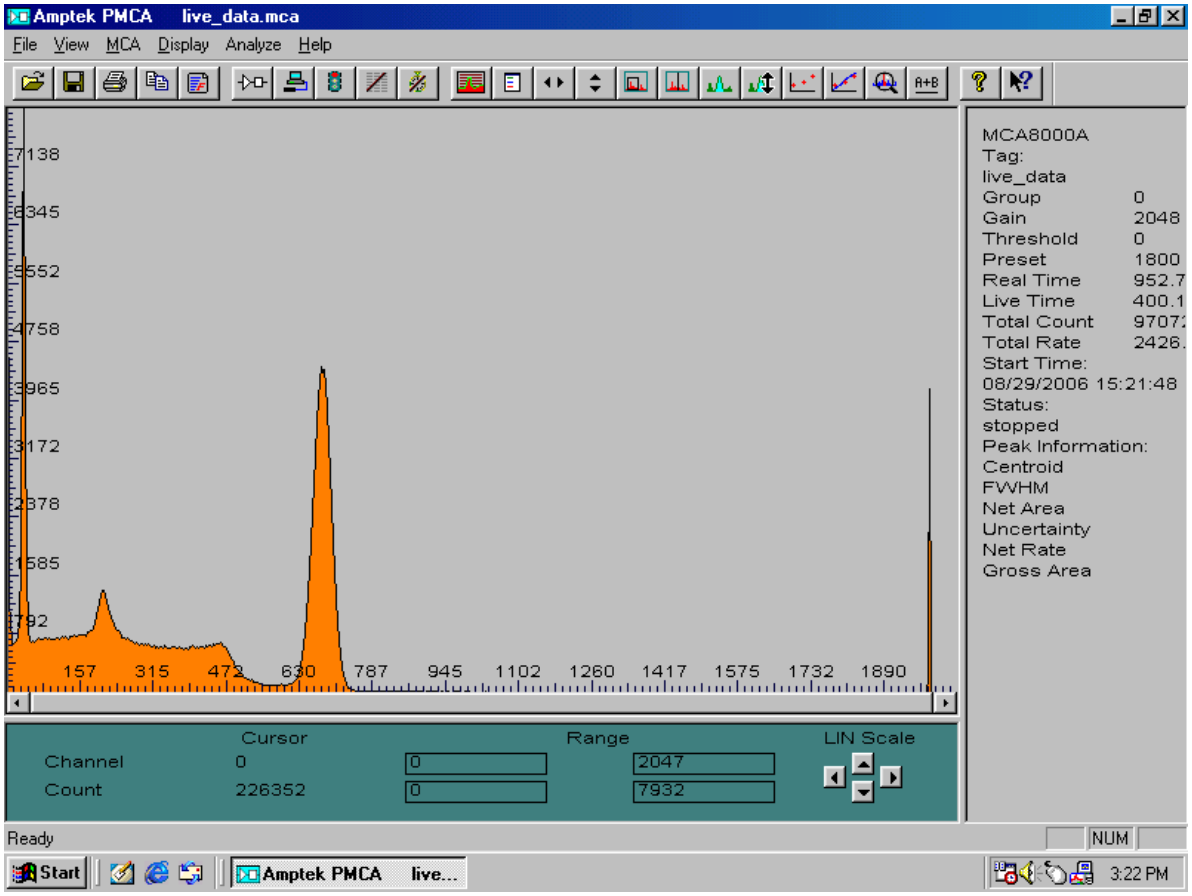


***Figure 6:*** *Cs-137 spectrum as plotted on the computer*

On the x-axis is plotted normalized intensity (which depends on the amplifier's gain setting). On the y-axis is the raw number of counts. Three features are immediately apparent:

-the **photopeak** (corresponding to complete absorption of the gamma ray's energy) at ~670 on the x-axis
-the **Compton edge** of the "plateau" at ~490
-the **Compton peak** at ~180

The Compton edge and Compton peak correspond to the maximum amount of energy that can be transferred by Compton scattering (i.e. a collision with 180° photon recoil). Note that the energy of the Compton peak plus the energy of the Compton edge add up to the photopeak energy (you can verify this visually just by looking at the graph), so the detector is linear.

Pay no attention to the "peaks" at extreme left and right; these are due to various instrumental effects and should be disregarded.

To **Stop** data acquisition, there is an option under the **MCA** menu.

Under the **Analyze** menu are various options for peak searching and fitting, and you can **zoom** in or out using the controls below the graph. Be cautious using the peak fitting routine, as it often returns results for nonexistent peaks; it is a good idea to estimate peak positions by eye and only using the software as a refinement of your visual assessment.

You can also **Save** your data under the **File** menu. Floppy disks are available to work on data at home; ask an instructor if there are none next to the computer. You can save the data as ASCII-format text and use your choice of plotting/analysis software to plot and study the data.

There is also a large book on the table which gives gamma ray energies for various sources. According to the book, the energy of the primary Cs-137 gamma ray is 661.65 MeV, so using this you can derive the (linear) relationship between the x-axis of the graph and true gamma ray energy. Then try the same for the other samples, which have one (or more) peaks at varying energies.

6. Closing down

When you are done for the day, you should close down the equipment and leave it in the same state you found it. To do this, simply reverse the steps from before:

- Shut down the computer.
- Shut down the MCA unit using the red button.
- Shut off the oscilloscope, if it is still on.
- Set the high voltage to zero and turn off the high voltage source.
- Shut off the main power supply switch at the rear of the unit.
- Return all radioactive sources to the sample container and see that a lab instructor returns the sources to the storage room.