Nuclear Physics Lab
Lab Manual

Energy Calibration using MCA

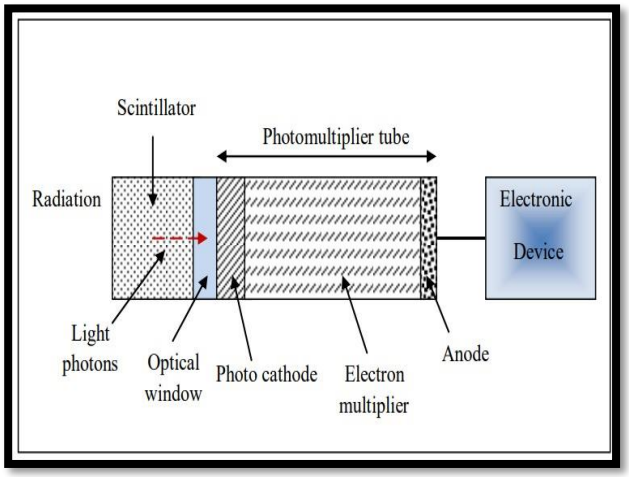
Aim: To calibrate the system using the standard energy sources for energy calibration and to determine the resolution of the NaI(Tl) detector for ^{137}Cs, ^{60}Co, and ^{22}Na gamma rays with MCA.

Apparatus required:

- MCA
- Connecting wires
- NaI(Tl) scintillator detector coupled with PMT and Preamplifier
- High voltage power supply
- Radioactive source and source holder
- Acquisition system

Theoretical Background:

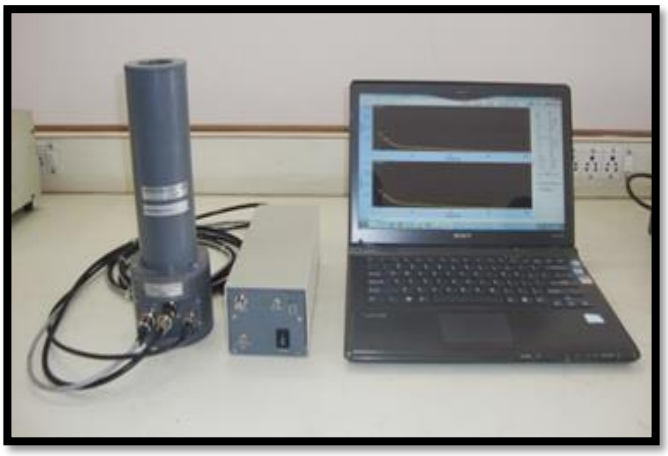
Detector assembly: Detector assembly consists of a scintillation detector, such as NaI(Tl); PMT and Preamplifier.



NaI(Tl) detector

NaI(Tl) (thallium-doped sodium iodide) is the most widely used scintillation material**.** NaI(Tl) as the scintillator is used in scintillation detectors, traditionally in nuclear medicine, geophysics, nuclear physics, and environmental measurements. The iodine provides most of the stopping power in sodium iodide (since it has a high Z = 53). These crystalline scintillators are characterized by high density, high atomic number, and pulse decay times of approximately 1 microsecond (~ 10^{-6} sec). They exhibit high efficiency for the detection of gamma rays and are capable of handling high count rates. The NaI(Tl) scintillator has a higher energy resolution than a proportional counter, allowing for more accurate energy determinations. This is due to their high density and atomic number which gives a high electron density. A disadvantage of some inorganic crystals, e.g., NaI, is their hygroscopicity, a property which requires them to be housed in an airtight container to protect them from moisture. The crystals are usually coupled with a photomultiplier tube, in a hermetically sealed assembly.

A multi-Channel Analyzer (MCA) is an important part of the nuclear spectroscopy system. MCA's major requirement is nuclear Pulse Height Analysis (PHA) in energy spectroscopy. The USB-MCA presented here, incorporates state of art technologies like FPGA, USB bus interface and precision analog electronics to meet the stringent system requirements in nuclear pulse spectroscopy. The resolution supported by the USB-MCA ranges from 256 channels to 1K/8K channels selectable via software, making it suitable for all spectroscopy applications of low resolution (e.g. NaI-PMT).



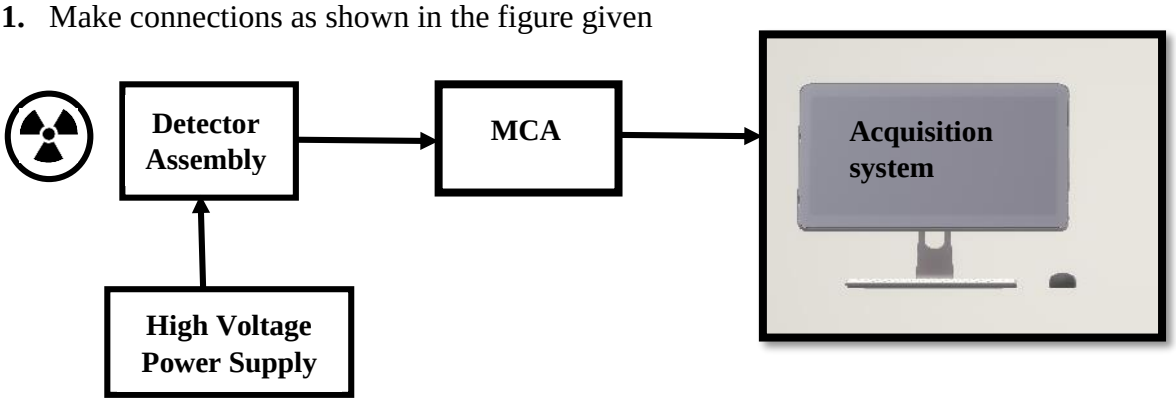
The USB bus interface of the MCA provides excellent connectivity with most of the new PCs and lap-top computers meeting the minimum requirements of PC. The ANUSPECT application software provided with the USB-MCA, seamlessly integrates with the hardware, featuring a range of standard functions required for analysis and acquisition.

Features:

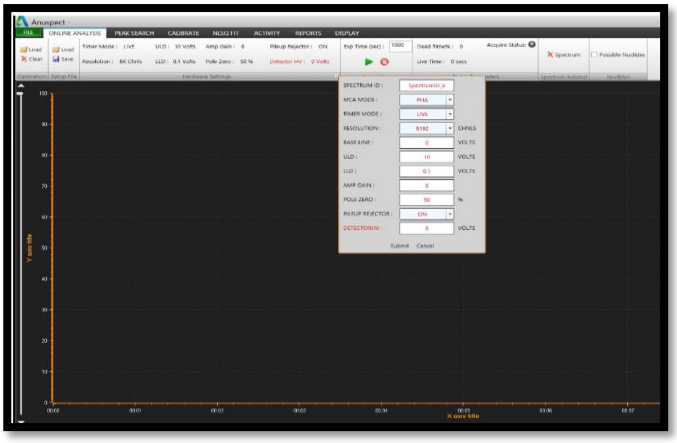
- Compact, 1K /8K MCA with USB interface.
- Built-in High voltage with an adjustable bias voltage to the detector.
- Built-in gain arrangement.
- Excellent MCA performance in terms of resolution.
- Universal connectivity to a wide range of PCs and notebook computers.
- Latest ANUSPECT Processing Software with the unit.
- Simple to install, operate and handle.
- Powered from 12V adaptor.

Procedure:

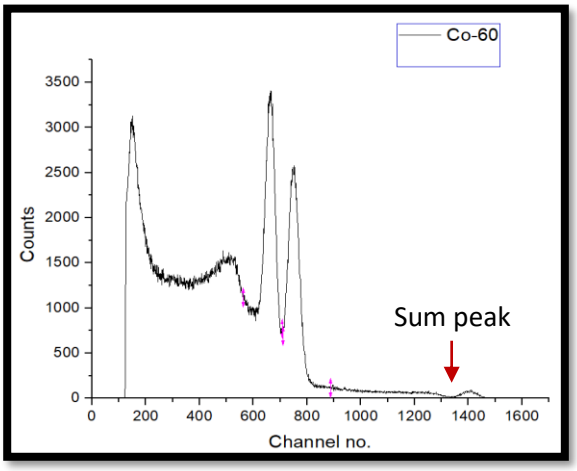
1. Make connections as shown in the figure given below

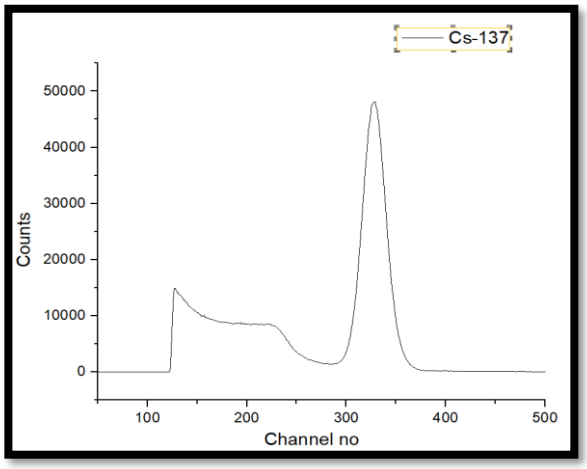


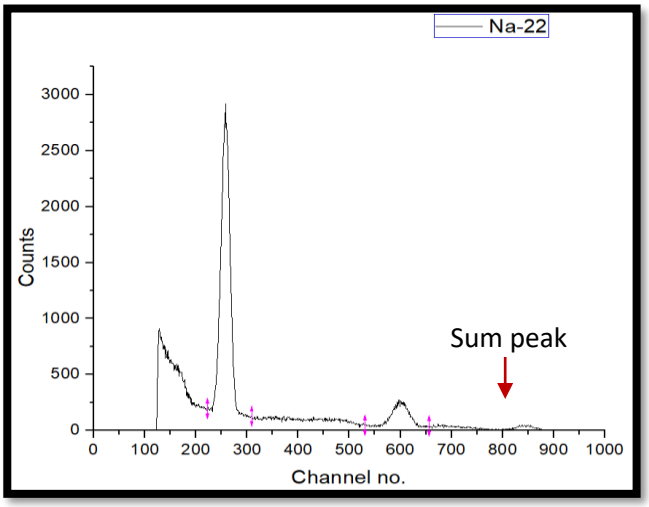
2. Place a radioactive gamma source on a source holder in front of the face of the detectors with the help of tweezers.
3. High Voltage Power Supply Unit is inside the MCA. So, connect the power supply to the detector and slowly increase the voltage up to the operating voltage of the detector, here, 500 V.
4. Input of the detector goes to MCA and output of MCA to the acquisition system.
5. Acquisition system should have Anuspect software.
6. Open the software and go to online analysis and set all the parameters as shown in fig below and click on the green button to start the acquisition.



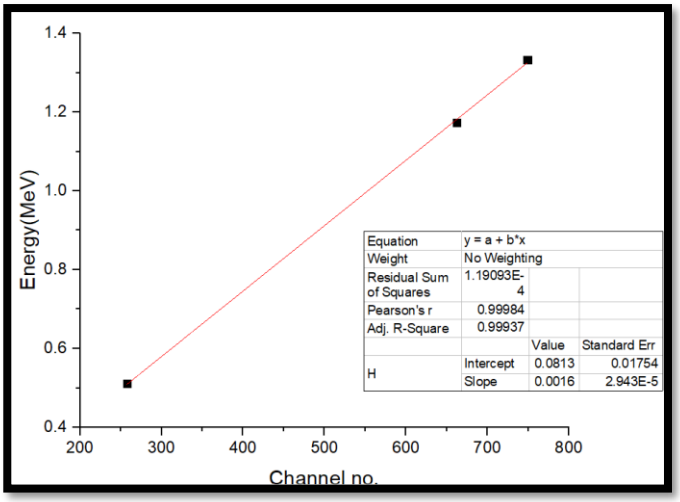
7. After the acquisition stop, save the spectrum by right click on the window and select the save spectrum option.
8. Using steps 6 and 7 by keeping all the same parameters, save the spectrum for all the sources in txt format.



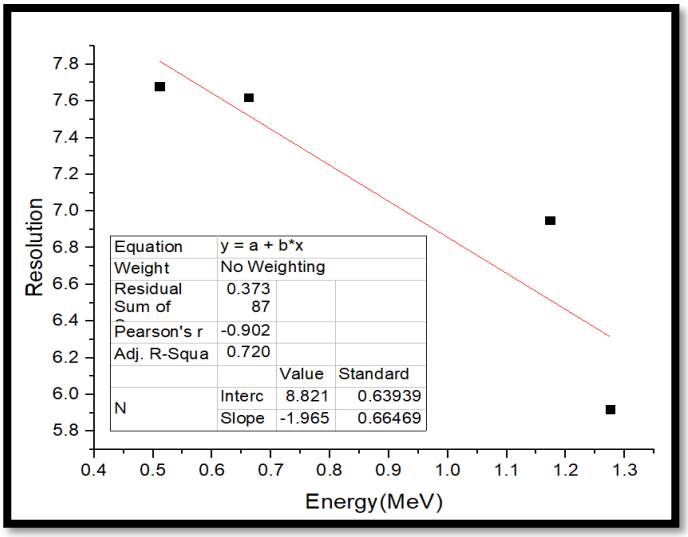




9. By using origin calculate FWHM, Centroid and resolution.
10. Plot energy v/s channel number by considering two known sources.



11. Plot energy v/s resolution.



12. Calculate the known gamma source's photopeak energy and error in the value.

Precautions:

(1) Always handle radioactive sources with a pair of tweezers. Never touch them with bare hands.
(2) Always power up and down the scintillation detectors slowly. An abrupt rise or fall in detector bias causes the sensitive components to fry.
(3) Do not sit in the proximity of the source while experimenting
(4) Avoid bringing food or water anywhere near the source
(5) Be careful while handling the High Voltage Power Supply. Proper shoes should be worn to avoid lethal electric shocks.
(6) Do not forget to power down the detector once the experiment is done.
(7) Turn the knobs lightly.

Courtesy: Bhavika
(Research Scholar)