Chapter 4

Experimental Setup and Measurements

The experimental measurements were divided into two parts: U-233 coating characterization measurements and GEM detector charge measurements. α-particle and γ-particle spectroscopy were performed for the U-233 coating. The main purpose of the α-particle and γ-particle spectroscopy was to determine the energy of the emitted particles from U-233 coating. To achieve that, the detectors were set to increase the energy resolution which will decrease each detector efficiency. The second part includes the GEM detector charge spectrum for U-233 coating a charge to digital converter (QDC). The charge spectrum has been analyzed using ROOT[49] software package. Then the measured data were analyzed and compared to the simulation results to identify the ionizing particle. The next sections discuss and analyze in detail the charge measurement results.

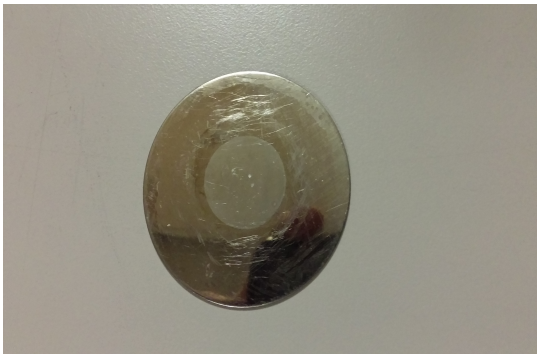
4.1 U-233 Coating Characterization

4.1.1 α-Particle Spectroscopy

The α-particle spectrum was measured using a Canberra spectrometer under vacuum connected a multi-channel buffer. The Canberra spectrometer model 7401 measured the spectra of α-particles in a low pressure environment. The pressure inside the chamber reached 16-20 μtorr. α-particles were detected after increasing the biased voltage to 20 V, which produced an analog signal that was sent to the multichannel buffer ORTEC 926.[65] Figure 4.1-a shows the multichannel buffer the multichannel buffer ORTEC 926 which allowed the user to select 8120 channels to specify the energy within 0.02 MeV.

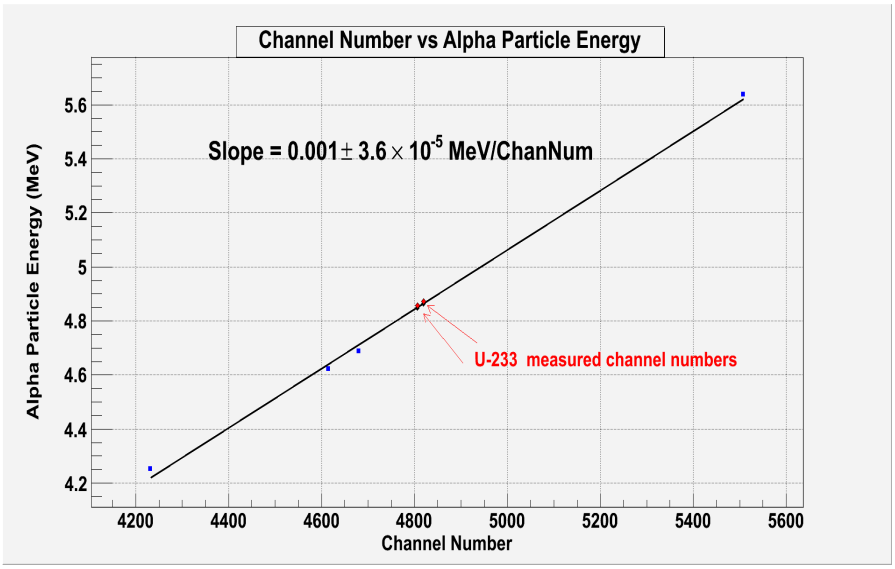
Standard α-particle sources were used to construct a calibration curve. These standard sources provided different α-particle energies that were in the range of 4.2-5.6 MeV. Figure 4.2-a shows calibration curve is linear with a slope of $0.001 \pm 8.8 \times 10^{-6}$ MeV/channel. and 4.86 ± 0.1 MeV as shown in Figure 4.2-b. Both peaks have low detection rate- less than 0.001 and a resolution of 4.1% for for peak of the higher rate.

(a)

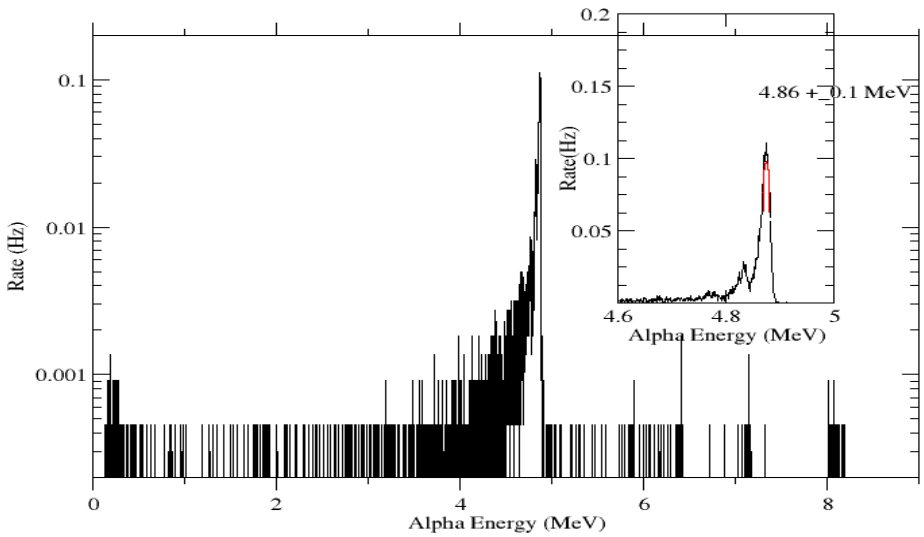


(b)

Figure 4.1: (a) Electronic modules used in α-spectruscopy (b) U-233 coating plate



(a)



(b)

Figure 4.2: (a)α-particle spectrometer calibration curve. (b) Energy spectrum of α-particles emitted from U-233 coating.

4.1.2 γ-Particle Spectroscopy

The spectrum of γ-particles from the U-233 coating was measured using a HP-Ge detector. Figure 4.3-a and Figure 4.3-b show the HP-Ge planar detector with a Canberra amplifier model 5615 and a KD model ND579 analog to digital converter (ADC) that were used to measure the γ-particle spectrum as shown in Figure 4.3-c.[71] The detector efficiency during the detection was 3%, and the detection time was 6000s.

The measured γ-particles emitted were low in rate, but it showed more than one peak measured from from the U-233 coating as shown in Figure 4.4. The measured spectrum was compared to the background spectrum that had the same detection time of 6000s. Table 4.1 shows the energies of detected peaks from U-233 coating spectrum, and ENDF-database for the X-rays and γ-decay energies were used to identify the expected radio-nuclei in the U-233 coating.

Energy of the photo-peak (keV) ± 1	Radioactive Nucleus	Type of Photon
17	U-233	X-rays
18	U-233	X-rays
29	Th-232	X-rays
41	U-233	γ-particle
43	U-233	γ-particle
63	Th-232	X-rays
123	Th-232	X-rays

Table 4.1: U-233 coating photo-energies collected by HP-Ge planar detector.

Consequently, the effect of the emitted γ-particles on the detector signal was negligible for two reasons. During the detector operation, the gain of the detector was insufficient to amplify any ionization from these photons. Second, the emitted γ-particles with the energies shown in Figure 4.4 easily penetrated the drift region without ionization even when the FR4 shutter was closed as shown previously in Figure 3.11.