Practice 1 of FYSKJM4710 – X-ray unit

The practice takes place at the X-ray unit in the basement of the chemistry building.

Equipment : 1 Pantak HF225 X-ray unit
1 Wellhöfer FC65G ionization chamber
1 Standard imaging MAX4000 electrometer
Some copper filters and socket

Guidance on the use of the X-ray unit and the measurements will be given. V = voltage, I = current

a) Position the ionization chamber so that its most sensitive volume is sited below the center of X-ray beam, and connect the chamber to electrometer. Start at a hight of 1.5 inches (two DUPLO®) Place a 1.5 mm aluminum filter in the filter holder. Use a X-ray field of V=60 kV, I=5 mA. Which rate (number of charges per second) is shown on the electrometer? Move the chamber closer and closer towards the X-ray tube (turn of the X-ray beam!) in steps of 3 inches (four DUPLO®); totally 5 steps. How dose the radiation intensity change with the distance from the source – is the decrease linear or inverse quadratic ($1/r^2$)?

b) Move the chamber back to the first position. Note again the production rate of ions. Increase systematically the current from 5 mA to 10 mA (keep the voltage constant), and note the rate at each mA. Make a graph of the rate as a function of the current. Give a comment – is the result as expected?

c) Turn the current back to 5 mA. Increase the voltage from 60 kV to 120 kV (keep the current constant), and note the rate for at least each 10 kV step. Plot then the rate as a function of voltage. Give a comment on the result. Use the Kramers spectrum to explain the phenomena (remember the lecture on not-radioactive radiation scours) – how dose the area below the X-ray spectrum increase (this area gives the total amount of radiation) with the voltage?

d) Define a X-ray beams half-value layer, HVL. By assuming exponential photon attenuation, how will HVL relate to the attenuation coefficients, μ?

e) Use V=100 kV, I= 5 mA and a 1.5 mm aluminums filter in the filter holder. Place the holder for extra filters. Move the chamber as close as possible to the filter holder. Measure the rate without extra filters. Place 1 mm of additional aluminums filters in the extra filter holder. Measure the ionization rate. Increase then the amount of filter in the extra holder. Make four measurements, ~1, 2, 4 and 6 mm. Plot the rate as a function of the thickness of extra aluminum (do not include the primary 1.5 mm Al). Find the half-value layer of aluminum. Repeat the measurements with a 220 kV beam, then with a 1.5 mm aluminum and 0.5 mm copper filter in the primary filter holder and additional copper filtration, four measurements ~0.5, 1, 1.5, 2 mm. Plot ionization rate as a function of the thickness of extra aluminum filters (do not include the primary 0.5 mm Cu). Find HVL. Use NIST of photon attenuation coefficients of aluminum and copper to find the photon energy which corresponds to your measured half-value layers.

f) The kerma calibration factor of the chamber is defined as: $N_K \approx \frac{D_{air}}{M}$

where D_{air} is absorbed dose in the chamber air volume and M is the electrometer readout. N_K of the actual chamber is 43.4 mGy/nC. What is the absorbed dose rate of the 100 kV-radiation (5 mA, 1.5 mm aluminum) and of the 220 kV-radiation (5 mA, 1.5 mm aluminum and 0.5 mm copper)? (use the measurements of **e)** without additional filtering). Discuss shortly the difference in absorbed dose rate from what you know about the changes in the radiation spectrum with kV and filtration.