CELET course 2024 - dosimetry exercise

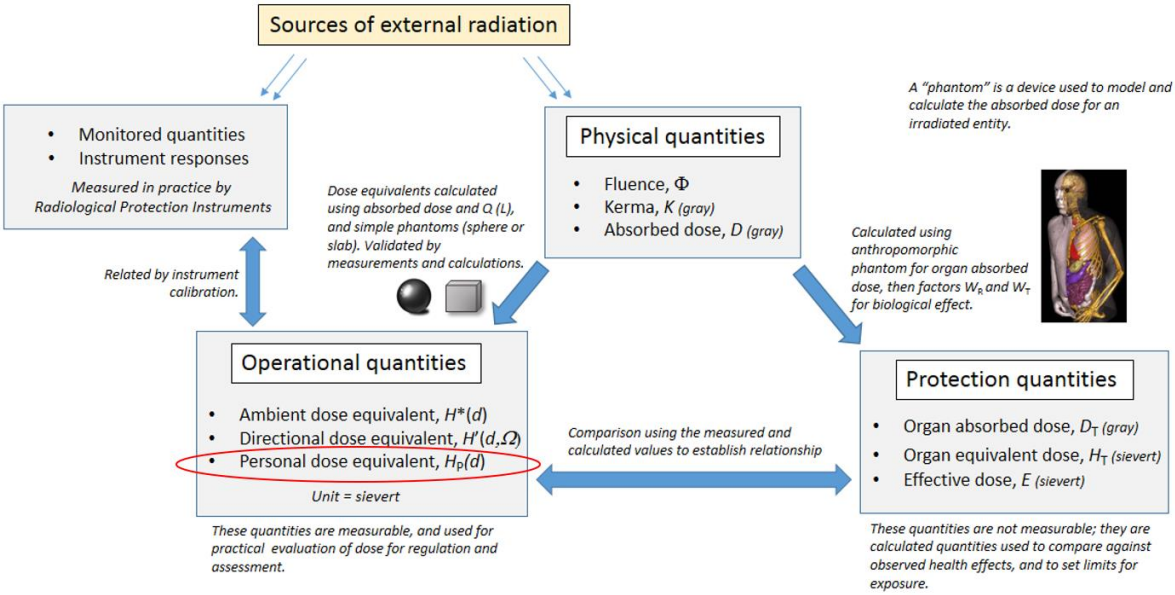
Several exercises will be carried out:

1. Radon measurements
2. Estimation of the relationship between the dose rate and distance from source
3. Measuring the energy spectrum of radiation from various sources
4. Impact of shielding on the dose rate and the energy spectrum of radiation
5. Demonstration of alpha radiation from a ^{241}Am source
6. Demonstration of the use of high and low activity gamma sources

These exercises involve handling low activity radiation sources. Below is a table showing radiation doses which we receive from various activities. Doses are given as effective doses.

Average natural background radiation:	3 mSv per year or ca 0.3 µSv/h
Flying in an aeroplane at 10 000 m:	5 µSv/h
Computed tomography (CT) - abdomen and pelvis:	10 mSv
Computed tomography (CT) –chest:	7 mSv
Radiography (X-ray) – extremity:	1 µSv
Radiography (X-ray) – dental:	5 µSv
Mammography:	400 µSv

Gamma dosimetric measurements will be caried out with **electronic personal dosimeters** that report the gamma **personal dose equivalent Hp(10)** in µSv/h. Hp(10) corresponds to the dose equivalent (absorbed dose * radiation quality factor) in soft tissue at the depth of 10 mm. Radon activity will be measured with the AlphaGuard dosimeter. See chart below for dosimetry units used in radiation protection and radiation research.



Source: https://en.wikipedia.org/wiki/Effective_dose_(radiation)

1. Radon measurement

Radon will be extracted from a ^{226}Ra source (see picture to the right)

Radon will be injected into a tight plastic container and:

1. The development of the gamma radiation dose rate will be measured on the outside of the container using a personal dosimeter

2. After 120 min the radon plus daughters activity inside the container will be measured with the help of the AlphaGuard dosimeter

3. Radon plus daughters will be measured inside a box containing pieces of pitchblende from Jachimov (https://en.wikipedia.org/wiki/Uraninite)

4. Radon plus daughter will be measured in the ground outside the university building

All radon measurements will be carried out with an AlphaGuard dosimeter: (https://www.bertin-technologies.com/product/radon-professional-monitoring/radon-alphaguard)

Results of gamma measurement

Time	**Dose rate (µSv/h)**
0 min	
15 min	
30 min	
60 min	
90 min	
120 min	

Results of the radon plus daughters measurement:

Source	**Activity in Bq/m^3**
Inside the container with collected radon gas	
Inside the container with pitchblende	
In the ground	

2. Distance, water filtering and dose rate

2a. Relationship between the distance from a point/ an area source and the dose rate

2b Impact of water (tissue density) filtering on the dose rate

Two sources will be used for measurements be the groups: a clock which represents an area source and a rod which represents a point source. Mark the source that you use.

Source: □ **Clock** □ **Point source**

Measure the dose rate at the given distance point from the source. Take measurements moving the dosimeter away from the source starting at 0 cm.

2a Measure	
Distance cm	**Dose rate µSv/h**
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
15	
20	
25	
30	
35	
40	
45	
50	
60	
70	
80	
90	
100	

2b Measure		
Distance cm	**cm of water**	**Dose rate µSv/h**
12	0	
12	3	
12	6	
12	9	
12	12	

Instructions

Let the dosimeter measure the dose rate for at least 5s at each distance

Check whether the results (2a) comply with the inverse-square law which says:
the dose rate is inversely proportional to the square of the distance from the source of radiation, according to the equation:

$$\text{Dose rate} \propto \frac{1}{\text{distance}^2}$$

What is the relationship between thickness of water and dose rate? This will aaproximatelly correspond to the depth-dose distribution in the body from an external source.

3. Measuring the energy spectrum of radiation from various sources

Measure the energy spectra of the following isotopes and compare them with reference spectra. Measurements will be performed with the PM1703MO-1A detector of POLIMASTER
http://www.polimaster.com/products/spectroscopic_personal_radiation_detectors/pm1703mo-1a/?print=true

The right peak of Cs-137 spectrum corresponds to 662 keV

Isotope	**Measured spectrum**	
Background		
^{137}Cs 		
^{133}Ba 		
^{207}Bi 		
^{22}Na 		
??? 		

4. Impact of shielding on the dose rate and the energy spectrum of radiation

Choose the source with the highest activity and check the impact of lead and aluminium filtering. How does filtering influence the spectrum? How does it influence the dose rate?

5. Demonstration of alpha particles from a 241Am source by a ZnS:Ag scintillation screen

In a dark room, a flat ^{241}Am source of 50 MBq will be covered by a phosphorescence plate containing ZnS:Ag. Phosphorescence will be visible. This scintillation screen provides very high intrinsic detection efficiency for alpha particles while having very low sensitivity for beta particles and gamma rays. Note the effect of thin piece of paper placed on a part of the source area. Take a picture with your mobile phone.

6. Demonstration of air ionisation by a weak 241Am source

An 241Am source from a smoke detector will be used to increase the electric conductivity of air. To this end the source will be moved towards electrodes of a paralyzer that are spaced apart so that no electric arc is created. The electric arc will be initiated when the air is ionized by the 241Am source.

7. Demonstration of the use of high and low activity gamma sources for radiobiology experiments

Three high activity ^{137}Cs sources for acute cell exposures will be demonstrated along with two low activity sources for chronic irradiation.

8. Demonstration of radiation detectors used in civilian and military radiological protection

Several modern/vintage active and passive radiation dosimeters will be demonstrated.