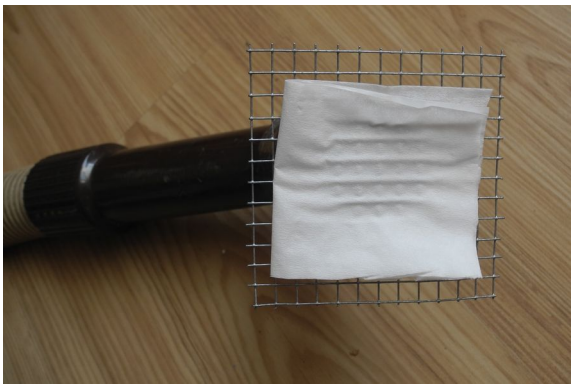
3.5.4 Filtering air using a vacuum cleaner

In the experiment 3.5.3, we were using the alpha radioactivity measurements to show that radon and its daughter products are commonly found in the air. It is possible to detect alpha radioactivity of air in your home, but it's quite rare. As has been said, the alpha decay must occur at a distance of a few centimeters from the sensor. With an energy of 9 MeV have alpha particles in the air a mean linear range of ca. 9 cm. To explore a greater volume of air, we can suck it through a filter and examine whether the filter becomes radioactive.

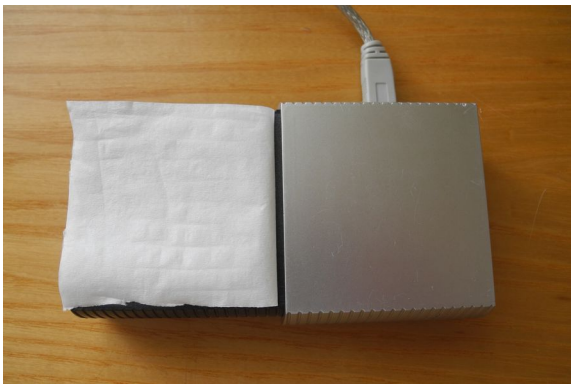
Experiment type:	Laboratory			
Duration:	75 min, simplified demo 15 min			
Equipment:	MX-10 camera and computer, mounting rails, vacuum cleaner, tissue paper, wire grid			
Settings:	*Radiation source:*	Other	*Exp. count:*	600
	Mode:	Spectrometer	*Exp. time:*	1 s
	Analysis type:	Basic	*Min. level:*	0
	Bias voltage:	20 V	*Max. level:*	20
	Continuous m.:	No	*Colormap:*	Hot
	Integral mode:	No		

Instructions: The MX-10 detector may be lying on the table with the sensor placed in horizontal position. Take a piece of tissue paper, fold it several times, and to get information of its possible radioactivity, make a 10-minute measurement before using it as an air filter. Place the tissue paper over the sensor detector and start measurement. If we after finishing the experiment, create an integral frame, it can look similar to Fig. 105 a. During the 10-minute measurement was registered one alpha particle.

Now we are going through to suck air through the tissue paper. The described measurement took place on the floor of the living room on the ground floor of a family house. We have prepared a vacuum cleaner and a wire grid, which support the lying tissue paper. When we turn on the vacuum cleaner, we place the grid with the tissue paper on the nozzle (Fig. 105 a) leave it running for 5 minutes. After turning off the vacuum cleaner, we place the tissue paper over the detector with its top side facing the detector (Fig. 105 b) and start the 10-minute measurement. When it is finished, we create an integral image (*Tools* → *Integral frame*) and have look at it (Fig. 106 b). The difference from Fig. 106 a is evident. The tissue paper shows



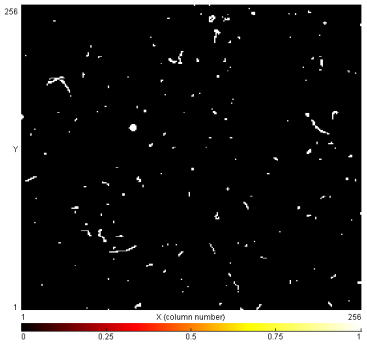
(a) Wire grid prevents sucking the paper into the nozzle.



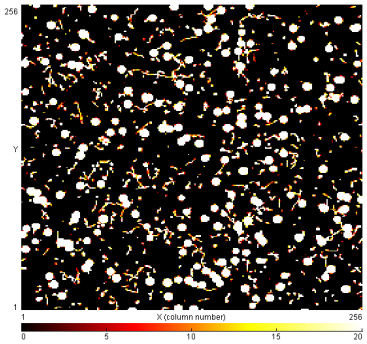
(b) The tissue paper is placed over the detector sensor.

Figure 105: Filtering air through a tissue paper.

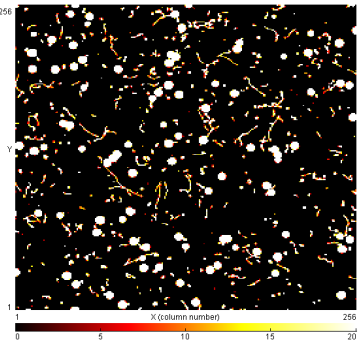
increased alpha radioactivity mainly. During the 10-minute measurement, 202 alpha particles were registered.



(a) Tissue paper before being used as air filter.



(b) After filtering the air in a living room (202 alpha).



(c) After filtering the air outside the house (95 alpha).

Figure 106: Measurement of the radioactivity of tissue paper. The exposure time was 10 min in all cases.

In addition to the visualization of the tracks we can also evaluate the measured energies of alpha particles. We will draw a histogram of energies of alpha particles (Fig. 107).

We see that the predominant alpha radioactivity is represented by particles of energy in the interval $\langle 5500\,\mathrm{keV}; 6500\,\mathrm{keV}\rangle$. The tissue paper could have collected the products of radon and thoron decay, which emit radioactivity alpha – ^{218}Po(6.002 MeV) and ^{212}Bi (6.051 MeV), or ^{216}Po (6.778 MeV). The energy of the alpha particles emitted from these radionuclides

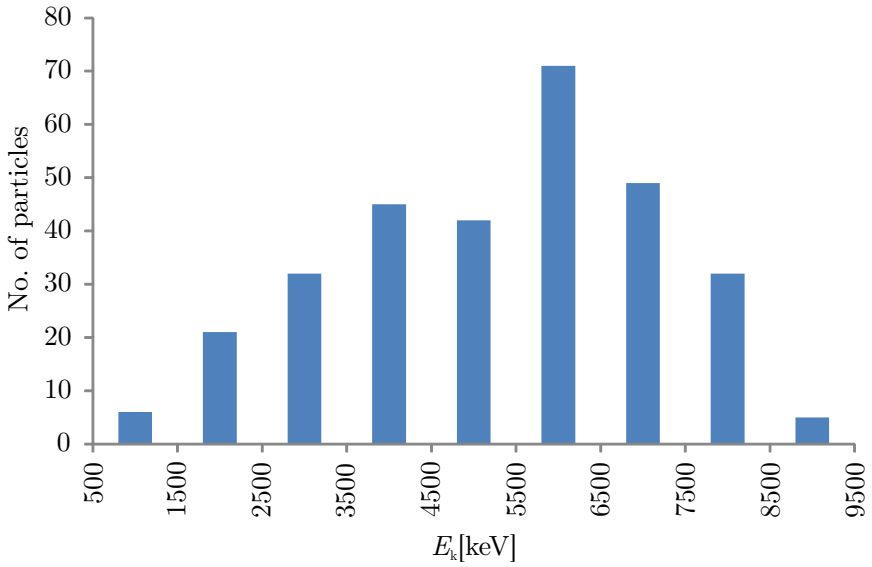


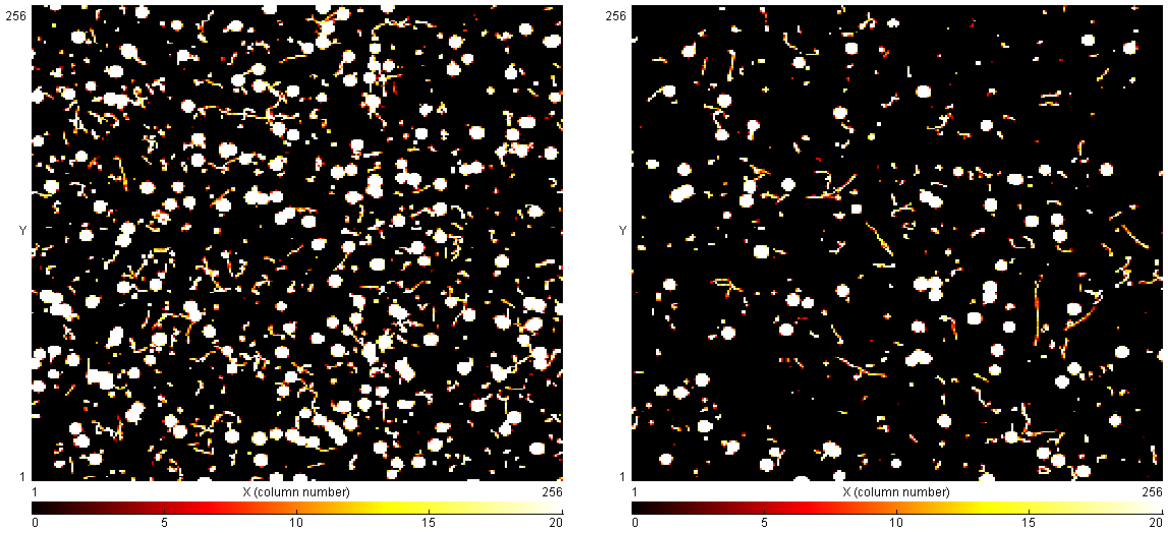
Figure 107: The histogram of energies of detected alpha particles emitted from tissue paper.

may fall within the aforementioned interval. In the histogram are represented also higher energies, which correspond to the decays of the ^{212}Po and ^{214}Po. Although our measurement was relatively short, the histogram confirms the presence of decay products of radon and thoron. To get better energy resolution we will experiment later with longer exposure times.

The experiment carried out inside the house can be repeated in the outdoor environment. The following suction of air through a tissue paper took place on the ground in the yard in front of the family house. The resulting integral image is in Fig. 106 b. The paper once again shows alpha radioactivity, but the number of registered alpha particles is only 95, approximately one half of what has been measured in the living room.

If we repeat the experiment in the room under the same conditions as before, the number of detected alpha particles would not be diametrically different. We can, however, change the conditions by changing the air in the room. Measurement result after thirty minutes of intensive ventilation can be seen in Fig. 108 a and for a comparison, again the measurement from the non-ventilated room in Fig. 108 b. During the measurement after ventilation were detected 77 alpha particles.

What can be concluded from our experiments? Radioactive radon and its daughter products manifest themselves mainly by increased alpha radioactivity showed by the tissue paper. The alpha radioactivity can be measured in indoors as well as outdoors experiments, and the



(a) In a not-ventilated room, 202 particles. *(b) In a ventilated room, 77 particles.*

Figure 108: Visualizations of the radioactivity of the paper handkerchief used as an air filter. The filtering took 5 minutes and exposure time was 10 minutes in both cases.

radioactivity inside the house is greater. The radioactivity measured in a not-ventilated room significantly decreased after airing. What is the cause of radioactivity of the filter (the tissue paper)? Decay products of radon are metal ions that bind to dust in the air and aerosol particles. When we suck the air through the filter, the aerosols can either pass through the filter or may stay captured on the filter. We have thus detected the radioactivity of these captured radionuclides after a close approach of tissue paper to the sensor.

The experiment also demonstrates how the radionuclides contained in the air infiltrate human body. When breathing, similar to the experiment with a handkerchief, are the aerosols captured in the respiratory tract, where the radionuclides emit all kinds of radioactivity. For humans is dangerous especially the alpha radioactivity in the lungs. It has the largest ionization ability and when it is stored locally in body tissue, it harms the most.

At the conclusion of the experiment, it should be said that the measured radioactivity is a natural part of the environment for living organisms. It is far below the value referred to in the health standards and a healthy human body is coping with this radioactivity well. Hygiene stations use methods of air filtering to determine the volumetric activity of radon in homes and other buildings. The volumetric activity of ^{222}Rn in the air tends to be from $4\,\mathrm{Bq\,m^{-3}}$ up to $10\,\mathrm{Bq\,m^{-3}}$.