Teaching laypersons an in depth understanding of ionising radiation

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Introduction

After large nuclear accidents contaminating the environment with radioactive substances the demands for information to experts, authorities, media, public and rescue teams first are overwhelming. Media journalists are confronted with the complexity of ionising radiation and without an appropriate education and experience, the published news can be both erroneous, out of proportion, and hard, not to say impossible, to interpret. No wonder that most laypersons may have preconceived and confused ideas about ionising radiation. The shortage of understanding the characteristics and behavior of ionising radiation is of special significance for first responders and rescue workers working in contaminated and potentially risky environments. These categories must be able to choose the optimum working strategy, often based insufficient information about the extent of the radiation accident and perhaps also lack of monitoring instruments. The aim of this presentation is to overview the stumbling blocks in teaching laypersons about ionising radiation and advice course providers how to navigate round these obstacles.

Obstacles

The barriers stopping a layperson "understanding" ionising radiation as such and making sense of how this strange phenomenon interacts with matter, detectors and so forth, can be many. As noted by Strom and Watson (1) there is vocabulary problems. The fact that several expressions in everyday language have a special meaning to the professionals, e.g. decay, element and activity, is confusing. Of greater importance though, is that media and laymen do not make a clear distinction between the radioactive matter and the emitted radiation. This mix-up means for example that sentences like "penetrates the skin", "absorbed by the body", and "leaking from the sarcophag" cannot be understood correctly unless you know if the author refers to matter or radiation. In the Nordic countries the mix-up of radioactive matter and atomic radiation is promoted by the media as they consistently use the term "radioactive radiation" for ionising radiation emitted from radioactive substances. It is interesting to note that the one-word expression "radiakstrålning" (strålning = radiation), found in the normative Swedish Academy´s Wordlist (2), is not in use neither in media in regulatory texts in Sweden.

The following list is not comprehensive but defines some of the lacking insights and preconceived notions that have to be considered introducing laypersons to the ionising radiation field

1. Vague knowledge about atoms, molecules, elements and matter
2. Make no distinction between radioactive matter and the atomic radiation emitted
3. Radioactive contamination is contagious like bacteria and viruses
4. Ionising radiation is associated with wave properties, not particles
5. Have no or only faint ideas how radiation energy is transferred to matter
6. Externally irradiated persons become radioactive

Teaching strategies

The following guidance is applicable to courses for laypersons when the educational goals are

a. The novice student shall get a clear understanding of most aspects of ionization radiation
b. The student shall be able to use and interpret the signal from counters, dosemeters and spectrometers
c. The student shall be able to take their own decisions how to act in a radiation environment, e.g. as a first responder

Note that the goals specified go beyond the basic demands of members of the public, requesting primarily risk information. Using and understanding measuring instruments, for instance, means that the student must familiarize with ionising radiation and its interaction with matter.

Evidently, the first lessons must devoted to brushing up basic physics, e.g. concepts like charge, force and energy, and to improve the knowledge about atoms, elements, matter and living cells.

"Ionising Radiation" is not clear concept to laypersons and should be introduced with care. Instead of jumping into ionization and radiation directly, it is better to start from the concept of "particles". The reasons and wins are several:

i. The concept "particles" is familiar
ii. Ionization radiation differs from radiation in general by its particulate behavior
iii. The quantization of electromagnetic radiation (photons) comes natural
iv. Collisions between atomic particles (i.e. ionising radiation) and matter is easy to take in

Once the crude picture of atomic radiation as a bunch of extremely small particles of extremely high velocities has matured, it is time to introduce minor corrections, e.g. photons are not real physical particles. Concerning photons, the energy is a sufficient characteristic, while wavelength and frequency can be left out without any impairment.

One example how the above thoughts are implemented is taken from the course for Custom teams mentioned below. In the very first lecture, the participants are presented a class-room demonstration to awake their curiosity (cf. Figure 1) and lead them right conceptually. In this live demonstration as few new concepts and quantities/unit as feasible are introduced. The energy scale, for instance, is in pJ instead of keV. During the demonstration the teacher interacts with the audience along the following lines. Apparently the stone emits entities of some kind and these entities have several distinct energies. We will later in the course see that these unknown entities behave like particles, so let us for now call them "particles" in lack of better knowledge. The concept "energy" is explored. From where obtains a particle its energy? Is the kinetic energy of the particles comparable to the energy in the milk? How come that a significant fraction of particles apparently passes through the milk without losing any energy? Yes, a particle must lose energy in the detector material in order to contribute to a peak. Yes, the stone also emits other type of particles not seen by the detector. Some particles are too penetrating, others lose all their kinetic energy before reaching the detector. A living organism can be injured by these particle, but only if they deposit energy. Dose is a concept you will meet frequently later in this course.

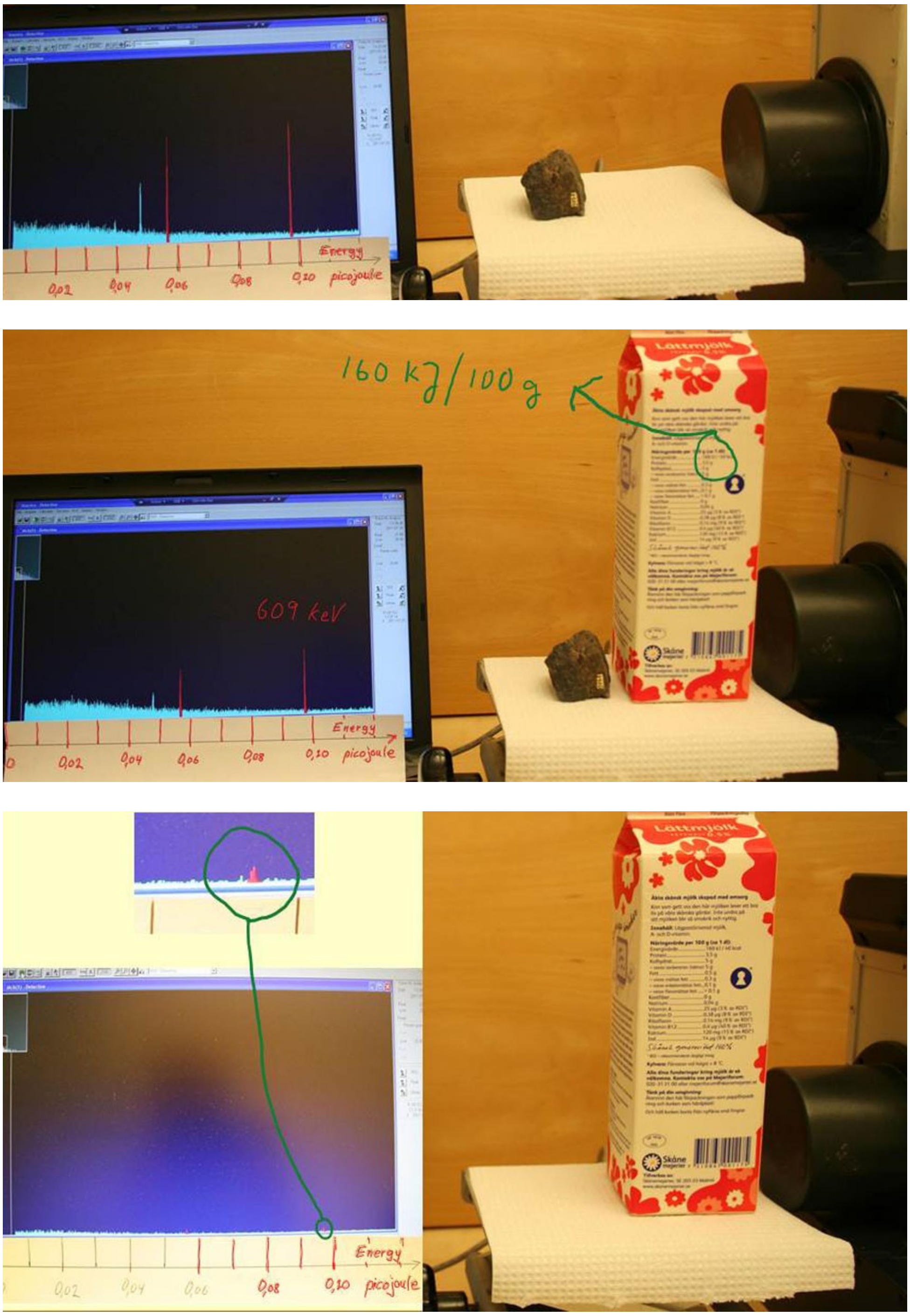

Figure 1. In a live demonstration the participants are shown the different peak growth rates caused by a stone, the stone blocked with milk, and milk only. In the demonstration the energy unit is joule throughout. (Beneficial to readers of this text, one of the peaks is noted in keV).

A course for Custom teams

The Swedish Radiation Safety Authority (SSM) requested in 2006 this author to take responsibility for a course training crew members of three Custom cars equipped with sophisticated systems for stationary and mobile surveillance of photon- and neutron sources in-situ. Within a time frame of three weeks the course participants, mainly middle aged persons without any previous insight into the field of ionising radiation, should be able to operate and interpret the gamma spectrometry and neutron detection systems of the car, as well as several handheld alpha-, beta-, gamma- and neutron sensitive detectors. The outcome was as expected. Teaching laypersons such an advanced curriculum in three weeks is not possible if the goal is a crew able to work independently and on a level comparable to a professional team. On the other hand, the odds for creating a useful crew in the know and comfortable with radioactive sources can be raised significantly, following the teaching strategies above.

The future

Blended class-room and web-based interactive course directed to lay persons needing a good understanding of ionising radiation is in the planning stage.

References

(1) Strom and Watson, Health Phys. 82, 373 (2002).

(2) Svenska Akademins Ordlista (SAOL), Distrib. by Nordstedts, Stockholm, (2006).