**Personal on-line dosimetry using computational methods**

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**Abstract**

Individual monitoring of workers exposed to external ionizing radiation is essential to allow application of the ALARA principle and follow up of the official dose limits. However, large uncertainties still exist in personal dosimetry, especially for neutrons and for inhomogeneous fields. Also, many practical problems exist for personal dosimetry, with many dosemeters getting lost and the reluctance of many workers to wear one or more dosemeters (ring, eye lens…).

Most legal dosimetry is done with passive dosemeters, which are analyzed after the wearing period in an accredited lab. Such dosemeters do not give alarms in high exposure situations, and the results are available only after one or several weeks. Active dosemeters are also widely used, although mostly only for ALARA purposes or for specific exposure situations. Especially in the nuclear industry they are used extensively, much less so in medical applications. Although the active dosemeters are dosimetrically and technically at least equivalent to passive dosemeters, their higher cost limits their use as only legal dosemeters.

The last years, hybrid dosemeters like the Instadose have come to the market. They are still passive (no alarms), but don’t require periodic returning to the dosimetric service.

Except for these hybrid dosemeters, not much evolution has taken place in personal dosimetry in the last 50 years. The techniques have evolved, from film dosemeters to thermoluminescent dosimetry methods, and now a majority of the dosemeters is based on optically stimulated luminescence. This has improved the performance of the dosemeters, but the method of dosimetry itself has not changed.

In an attempt of reinventing dosimetry by using the modern evolutions in simulations, artificial intelligence and computer vision, the PODIUM project was set up. PODIUM was a short feasibility project, funded by the EC CONCERT programme.

The objective of the PODIUM project was to improve personal dosimetry by an innovative approach: the development of an online dosimetry application based on computer simulations without the use of physical dosemeters. Operational quantities, protection quantities and radiosensitive organ doses (e.g. eye lens, brain, heart, extremities) can be calculated based on the use of modern technology such as personal tracking devices, flexible individualized phantoms and scanning of geometry set-up. When combined with fast simulation codes, the aim was to perform personal dosimetry in real-time.

We applied and validated the methodology for two situations where improvements in dosimetry are urgently needed: neutron workplaces and interventional radiology. An online application in which we calculate individually the level of occupational exposure was developed. For that purpose, the spatio-temporal radiation field, including its energy and angular distribution, needed to be known. We use input from dose monitors in the neutron workplace and radiation dose structured reports (RDSR) from the x-ray machine used in interventional radiology and we capture real movements of exposed workers and transfer this to the calculation application.

We will show that this feasibility study gave good results. Several validation and test measurements were done in different hospitals, and in 2 workplace fields with significant neutron exposure. Personal doses could be calculated within acceptable simulation times, just based on captured movements of the workers and information of the radiation fields. These doses agreed with the results from physical dosemeters within the standard uncertainties that are accepted in personal dosimetry.

This PODIUM project was just the first step toward such novel dosimetry. This PODIUM dosimetry method can overcome the problems that arise from the use of current passive and active dosemeters. These simulation results can also be used to visualize the radiation in near real time. This will increase awareness of radiation protection among workers and will improve the application of the ALARA principle, and it can also be used in training modules. The use of neural networks and big data will help in further reducing simulation time, making real time simulations and dosimetry without physical dosemeters possible in the near future.