Dose Coefficients for Radiation Protection at Present and Future RIB facilities

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For an assessment of effective dose E to workers or to the public, dose coefficients are used. These coefficients relate the activity of a radionuclide and the operational dose quantities delivering an estimate of E.

- The external dose coefficient $h^*(10)$ (historically denoted the "gamma-constant" Γ). This coefficient is the ratio of the ambient dose equivalent rate $H^*(10)$ in a distance of 1 m and the activity of a radionuclide. It is usually expressed in mSv h^{-1} GBq^{-1}. External dose coefficients for radionuclides with half-lives longer than 2 minutes are tabulated [1]. The half-live cut-off has been motivated by the fact that shorter-lived nuclides cannot be handled in a classical laboratory environment.
- The inhalation and ingestion dose coefficients e_{inh} and e_{ing} are the ratio of the committed effective dose E_{50} and the inhaled or ingested activity of a radionuclide. Their unit is mSv/Bq. The coefficients are available for radionuclides with half-lives above a few minutes and for nuclides occurring in the nuclear fuel cycle, e.g. in [2].

Present and future Radioactive Ion Beam (RIB) facilities provide intense, accelerated beams of radioactive ions for scientific experiments in nuclear, material and astro-physics. Personnel working in an RIB facility and the public living in the environments may be exposed to external radiation and to internal contamination after incorporation of radioactive species. The consequences of such exposures could be particularly important after an incident in the facility followed by an uncontrolled release of radioactive isotopes.

Presently available dose coefficients do not cover the spectrum of radionuclides to which workers or public may be exposed at RIB facilities:

- Many short-lived exotic isotopes may be produced on-line at an RIB facility in quantities which produce significant ambient dose rates. None of the above coefficients are presently available because of the half-live cut-off.
- The use of actinide spallation targets (^{238}U, ^{232}Th) for isotope production leads to the unwanted production of lighter actinides, for which the coefficients e_{inh} and e_{ing} are unavailable. Figure 1 demonstrates the lack of inhalation dose coefficients e_{inh} for spallation products from ^{238}U.

For dosimetry and radiation protection at present and future RIB facilities it is necessary to enlarge the available set of dose coefficients. The paper discusses the derivation of those coefficients:

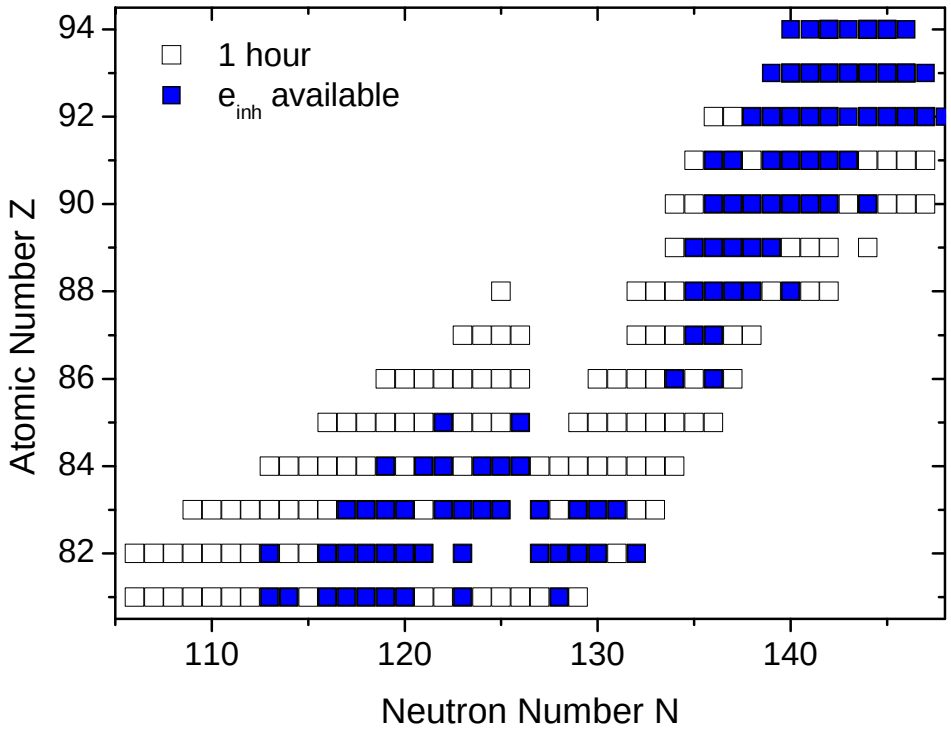

Fig. 1.
Alpha-emitters present in a ^{238}U spallation target 1 hour after proton irradiation (white) and isotopes with available inhalation- and ingestion coefficients (blue)

- External dose coefficients $h^*(10)$ for the estimation of ambient dose equivalent H*(10) from external radiation requires the summing of the dose contributions over all decay branches (γ and β) of a radionuclide. For very short-lived isotopes it may be suitable to include the decay of the daughter product(s). Tabulations of decay data such as [3] may serve as an input to the calculation.

- The calculation of inhalation and ingestion dose coefficients e_{inh} and e_{ing} is based on the models of the respiratory tract [4] and the gastro-intestinal tract of the ICRP. The kinetics of radioisotopes in these tracts must be described before calculating and summing the dose to the all target organs in the body from deposited nuclides to obtain committed effective dose E_{50}.

References

[1] Petoussi et al., GSF-Bericht 7/93, Forschungszentrum für Umwelt und Gesundheit GmbH, (1993) ; Conseil fédéral suisse, Ordonnance sur la radioprotection, http://www.admin.ch/ch/f/rs/814_501/index.html/
[2] International Commission on Radiological Protection, Dose coefficients for Intakes of Radionuclides by Workers, ICRP Publication 68 (1994)
[3] Nudat 2.5, http://www.nndc.bnl.gov/nudat2/
[4] International Commission on Radiological Protection, Human Respiratory Tract Model for Radiological Protection, ICRP Publication 66 (1994); International Commission on Radiological Protection, Human Alimentory Tract Model for Radiological Protection, ICRP Publication 100 (2006)