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Low Dose

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Low Dose

Dear Editors:

Low doses of radiation are frequently inferred to mean doses of the order of 10-100 mGy, regardless of the end point or the nature of the irradiation, as if the energy were deposited uniformly through all targets. Yet, the fluence in a charged particle beam at which there is an average of 1 charged particle transit per target leaves 37% of the targets untouched. At an average of 3 transits per target, 5% of the targets experience no particle transits. Only at an average of 5 transits per target do 99% of the targets achieve one or more transits. One might consider this to be the lowest meaningful fluence for 1-hit detectors. For 2-hit detectors an average of 7 transits per target are required to achieve 2 or more hits in 99% of the targets. These conclusions arise from the cumulative Poisson distribution. To translate these numbers into the lowest meaningful dose requires consideration of target size and particle LET.

The geometric cross sections of biological targets range from about 10^{-2} to 10^{2} μm², or about 4 orders of magnitude. Particle stopping powers range from about 2 to 2×10^{5} MeV g^{-1} cm^{-2}, or about 5 orders of magnitude. Thus the lowest meaningful dose ranges over 9 orders of magnitude, depending on the particle, its energy, and the biological end point. What then is the validity of a universal numerical specification of "low dose"? What is the validity of low dose RBE's, or of the application of the Sievert to evaluate the hazard from radon to the general public or the hazard to astronauts from galactic cosmic rays. To what end points and at what dose level are these applicable?

We urge that a more appropriate terminology is "low fluence," and that the numerical specification of a minimal meaningful low fluence be tailored to the end point of interest, clearly orders of magnitude different for mammalian cells and bacterial spores, different for cell killing and for mutation, and that experimental values of fluence be reported as well as the dose. It seems absurd to describe in terms of dose an irradiation in which many (perhaps most) cellular targets experience no particle transits, as in the case of the annual 1 mGy limit of dose to the general public prescribed by the NCRP.

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Response to Katz and Cucinotta

Dear Editors:

Katz and Cucinotta point out that the "lowest meaningful dose," according to them, ranges over 9 orders of magnitude. In fact, as far as biological effects are concerned, values of relative biological effectiveness (based on dose) range only over about a factor of 20 or so, 1 to 2 orders of magnitude. Thus the concept of a "low dose" is quite convenient in radiobiology for most radiations in spite of what these authors say.

The idea that these authors have that 99% of the targets need to have one or more transits seems very dubious and thus the "low fluence" terminology they suggest also seems questionable.

Nevertheless, NCRP has a profound interest in the possibility that fluence may be a more useful concept than absorbed dose or equivalent dose for some radiation protection circumstances, such as space perhaps. To this end NCRP currently has a committee, SC 88, "Fluence and Event Based Methods for Radiation Protection in Space," which is considering the merits of different approaches and will have a report on the subject in due course.

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