## EGSnrc in the cell nucleus

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### ABSTRACT

General purpose Monte Carlo codes such as EGSnrc are not usually touted as being useful for the determination of stochastic quantities, firstly because such quantities are generally required at length scales at which the physics assumptions become unreasonable but also because macroscopic source descriptions lead to very inefficient simulations. Standard geometric and importance based variance reduction practices are often invalid due to the way in which energy per event is tallied. There are potential advantages in being able to apply a general purpose codes to microdosimetry problems, in particular being able to use a wider set of materials and to include contributions from upstream and downstream material that may generate complex non-equilibrium fluence. The successful application of EGSnrc to small mm sized air cavities supports its usage in micron size volumes of density 1 gm/cc. The human cell-line, CGL1, is an example of a biological system that shows sensitivity to variations in the energy of low-LET radiation sources (e.g. X-rays and beta sources). The explanation appears to lie in radiation induced damage on the scale of the cell nucleus. Specific energy and lineal energy are stochastic quantities which have been computed with EGSnrc and which unlike dose and LET need to be computed per source particle. In order to achieve reasonable statistics in micron sized volumes for a uniformly distributed source a technique known as detector fluctuation has been used. One approach is to divide the cell layer up into an array of micron sized volumes, however the memory requirement to do this over a scale of cm's quickly escalates to Gbytes. In this paper an alternative method is proposed where events occurring within the cell layer are recorded and at the end of each history, a single energy deposition event is selected at random from the list and translated to deposit the energy at a randomly sampled point within the cell volume. All other events in the particle track are translated accordingly and the total energy deposited within the cell is determined and tallied. Typically hundreds of events need to be post-processed which has an impact on the amount of time it takes to complete the history. The dose-weighted mean lineal energy calculated for a 1x5 micron cylindrical nucleus was 4 keV/micron for a 30 kVp Mo-target X-ray source compared with 0.20 keV/micron for a Sr-90 beta emitter. The biological data from this system indicates a 4-fold difference in RBE for the two radiation sources in the low dose-rate limit which corresponds to an activation threshold of approximately 2 keV/micron deduced from the lineal energy spectra computed for this target size.