Using laser-driven ion sources to study fast radiobiological processes

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The relative biological effectiveness (RBE) is the comparison of the biological effectiveness of one type of ionizing radiation relative to another. RBE is strongly dependent on linear energy transfer (LET) of radiation, and the relevance and significance of spatial distribution of DNA damage to RBE were originally recognized from biophysical considerations. Although the concept of "clustered lesions" has gained general acceptance in the field and successfully explains the RBE-LET relationship, it is not known whether each fast process (ex. ionization, excitation, radical formation, etc.) contributes equally in generating DNA damage after exposure to high- and low-LET radiation. Thus, to the best of our knowledge, the following radiobiologically important question has not yet been answered: "Do the types of damage that comprise clustered lesions differ between high and low LET radiation ?" A better understanding of early and rapid processes, within the time scale of psec to nsec after the ion particle-irradiation, is important not only from a basic radiobiological standpoint but also from the standpoint of biological applications of radiation, such as radiation risk assessment and radiotherapy.

We address the potential usefulness of laser-driven radiation, especially of laser-driven ion particles, for the study of fast processes. Ideas involving pump and probe experiment will be proposed. The effects of a single ion bunch (i.e. the pump) impacting a target molecule can be monitored by a diagnostic (probe) pulse. Because water is the most abundant molecule in living cells, it can be a very important target in such molecular studies. Physical features of the probe pulse (such as absorption, fluorescence, small angle x-ray scattering) can reveal changes of (target) molecular polarization, formation of radicals or cavities in water produced by ions. When combined with detailed simulations, this unique class of experiments can address relatively unexplored key physical/chemical post-irradiation processes and can therefore be indispensable for obtaining further insights into the dynamic mechanisms underlying particle radiation effects.