SHORT-TERM SCIENTIFIC MISSION - Scientific report

I have spent 5 days from November 15th, 2004 till November 19th, 2004 with Mr. Z. Francis and my colleague Dr S. Incerti from CENBG, France, at the Institute of Radiation Protection (ISS) - German GSF National Center for Environment and Health in Neuherberg, Germany - in the framework of the COST P9 working group 5 (study of track structure in cells, Chair: H Paretzke). During this stay, I have benefited from the expertise of Dr Werner Friedland to discover and learn the PARTRAC Monte Carlo simulation tool. This tool represents today the state of the art in computer simulation of DNA damage after cellular irradiation. Our laboratory in Clermont is equipped with a neutron source allowing us to irradiate individual living cells with 14.1 MeV neutrons. In particular, we studied cellular survival and the chromosomal lesions, after irradiation by neutrons of 14.1 MeV with very low dose and dose rate on a line of human melanoma and glioblastoma whose common characteristic are a large resistance to photon's irradiations.

The PARTRAC code will allow us to predict the consequent damages by the neutrons in the cells. For example, most of the secondary particles created by the fast neutrons are protons and alphas. The cell is simulated using spherical cytoplasm geometry of radius 12 μm and a concentric cylindrical nucleus of height 5 μm and radius 7.5 μm. The nucleus is divided into 46 regions with volumes equal to the corresponding chromosome volumes. The chromatine is modelised by 333000 linear elements of 18 kbp length. All the details about the nucleus geometry may be found in [1].
We ran the PARTRAC code with different type of incident particles (proton and alpha) to understand the data that it could provide and how to use it in our specific study. For an irradiation rate of 5 alpha particles per cell, PARTRAC predicts a total number of single strand breaks equal to 214 ± 28 and a total number of double strand breaks of 40 ± 5. These numbers have been averaged on 10 trials. The total number of hits along the structure reaches 2338 ± 206.

In the case of the irradiation of cells of human melanoma, we have measured a strong decrease of survival rate between 0 and 5 cGy, followed by a plateau of the survival curve between 5 and 30 cGy. This phenomenon, can suggest a mechanism of induced radioresistance or cellular repair. This is clearly surprising that this particular structure of the survival curve appears only in the case of very low dose rates (order of 5 cGy.h-1). We will compare these measurements to PARTRAC predictions to understand what could be the origin of such phenomena. We also expect to be able to connect the GEANT4 software with PARTRAC in order to simulate experimental irradiation facilities and allowing us to predict the mechanisms of damage following a targeted irradiation. The COST P9 program provides thus an ideal framework enabling collaboration between the French groups (LPC Clermont and CENBG) and GSF on both experimental and theoretical aspects of cellular irradiation.

[1] W. Friedland *et al.*, Calculated DNA double-strand break and fragmentation yields after irradition with He ions, to appear in Radiation Physics and Chemistry (2004)