STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

BOOK OF ABSTRACTS

SCK•CEN-BA-49

1st BHTC (Belgian Hadrontherapy Centre) in vitro Workshop

Fondation Universitaire | Universitaire Stichting
Emile Francqui room
Rue Egmont 11
1000 Brussel

Brussels | October 25, 2012

bhtc.sckcen.be

federal public service
HEALTH, FOOD CHAIN SAFETY AND ENVIRONMENT

SCK•CEN
Boeretang 200
BE-2400 MOL
Belgium
http://www.sckcen.be

BOOK OF ABSTRACTS
SCK•CEN-BA-49

1st BHTC in vitro Workshop

Fondation Universitaire | Universitaire Stichting
Emile Francqui room
Rue Egmont 11
1000 Brussel

Brussels | October 25, 2012

SCK•CEN, Boeretang 200, BE-2400 MOL, Belgium

Contact: Sarah Baatout

E-mail: sarah.baatout@sckcen.be

Organising committee

Frank Deconinck

Sarah Baatout

Stéphane Lucas

Marjan Moreels

© SCK•CEN
Studiecentrum voor Kernenergie
Centre d'Etude de l'Energie Nucléaire
Boeretang 200
BE-2400 MOL
Belgium

http://www.sckcen.be

Status: Unclassified

RESTRICTED

All property rights and copyright are reserved. Any communication or reproduction of this document, and any communication or use of its content without explicit authorization is prohibited. Any infringement to this rule is illegal and entitles to claim damages from the infringer, without prejudice to any other right in case of granting a patent or registration in the field of intellectual property.
Copyright of the individual abstracts and papers rests with the authors and the SCK•CEN takes no responsability on behalf of their content and their further use.
SCK•CEN, Studiecentrum voor Kernenergie/Centre d'Etude de l'Energie Nucléaire
Stichting van Openbaar Nut – Fondation d'Utilité Publique - Foundation of Public Utility
Registered Office: Avenue Herrmann Debroux 40 – BE-1160 BRUSSEL
Operational Office: Boeretang 200 – BE-2400 MOL

Contents

Foreword

The aim of the Feasibility Study for a Hadron Centre ordered by the Federal Office of Health and Social Affairs is to investigate whether a Hadron Centre would meet clinical and social needs in Belgium.

The technology required for Hadron therapy, especially using carbon nuclei, is still in a demonstration phase. Only a few pilot centres worldwide are in operation. The design of such centres slowly converges towards more standardised setups, but major technological advances concerning both the accelerator and the gantry are still expected in the next decade.

Similar considerations hold for the clinical applications: a few are proven through the experience of foreign centres; others can be expected based on physical characteristics of hadron beams and their interactions with matter, on extrapolations of clinical knowledge, or on deductions from fundamental radiobiological research.

It is this last point which is the main subject of todays workshop. Radiobiological research, mainly through in-vitro studies or animal models, adds essential elements to the understanding of the processes that may ultimately lead to new science-based clinical applications.

Belgium is renowned worldwide for the quality of its medical care. Its industry is on the forefront of accelerator developments as well as of installations for protontherapy. Finally, its radiobiology departments play a leading role in Europe and abroad.

This workshop will, we hope, be the first of a series and give rise to long lasting and fruitful collaborations between the participants and participating centres.

Frank Deconinck
President of BHTC

Programme

10:00 - 10:30	Welcome coffee
10:30 - 10:40	Welcome words and presentation of the aims of the workshop | *S. Baatout & S. Lucas*
10:40 - 11:10	The Belgian Hadron Therapy Center project: motivation and status | *W. De Neve*
11:10 - 11:40	Hadrontherapy physics and the Namur in-vitro irradiation facility | *S. Lucas*
11:40 - 12:10	Biological aspects of hadrontherapy | *M. Moreels*
12:10 - 12:40	Investigation of low dose hypersensitivity mechanisms following irradiation with charged particles | *A.C. Heuskin*
12:40 - 13:20	Walking lunch
13:20 - 13:50	Influence of carbon ion radiation on metastasis related genes in human prostate cancer cells | *A. Suetens*
13:50 - 14:20	Survival fraction simulation code for in-vitro hadrontherapy and potential extension to treatment planning software | *A.C. Heuskin*
14:20 - 14:50	Microdosimetric characterization of a therapeutic charged particles beam | *S. Chiriotti*
14:50 - 15:20	Study of the effects of X-ray and alpha radiations on the interactions between tumor cells and endothelial cells: how to enhance their therapeutic efficacy | *H. Riquier*
15:20 - 15:50	Charged particle effects on human endothelial cells | *C. Rombouts*
15:50 - 16:30	Table Ronde, final discussion and coffee

The Belgian Hadron Therapy Center project: motivation and status

Wilfried De Neve

Department of Radiotherapy, UZ Gent, Gent, Belgium

Abstract not available

Hadrontherapy physics and the Namur in-vitro irradiation facility

Stéphane Lucas,
NAmur Research Institute for LIfe Sciences (NARILIS), Research Center for the physics of Matter and Radiation (PMR), University of Namur – FUNDP

Abstract

Hadron-therapy is one of the new modalities developed for the treatment of cancer,. However, the studies performed about the potential benefit of such treatments emphasize that more data and fundamental works are needed to better understand mechanisms happening at the cellular level. For this purpose, a reliable broad beam particle in-vitro irradiation facility (from proton to carbon) has been developed to be used for radiobiological experiments.

The system includes a particle accelerator, a beam diagnostic device and an irradiation station used to irradiate a monolayer of adherent cells either alone or in co-culture. Cells are seeded on a kapton foil and are immersed in culture medium and kept in sterile conditions during the irradiation. Particle type, dose, dose rate and LET are chosen according to the user requirements. Up to 100.000 cells are irradiated during a single experiments.

For protons, alpha particles and carbon ions, dose-rates ranging from 0.1 to 10 Gy/min are easily obtained. For protons, incident energies going from 300 keV to 4 MeV can be used to get LET going from 50 to 10 keV/µm. For alpha particles, incident energies going from 450 keV to 6 MeV correspond to LET ranging from 200 to 90 keV/µm. 12 MeV carbons ions were also been used to perform irradiation with a corresponding mean LET of 282 keV/µm. Error on dose rate is less than 7 % for 25 keV/µm proton beam , 100 keV/µm alpha beam and 280 keV/µm carbon beam.

Any other type of particles up to carbon can also be produced although they have not yet been investigated.

With this setup, one can study the survival fraction and determine the RBE of a selected particle and cell line. Typical biological bioassays (cell viability, DNA damages and DNA synthesis, …) are available specially to study a set of phenomena, called the non-targeted effects, that have been discovered recently and which challenges the idea that the only critical effect of ionizing radiation in the cell is the DNA damage and that less incident energy means less death, fewer DNA breaks and fewer mutations. Those effects are: adaptive response (AR), bystander effect (BE), genomic instability (GI), inverse dose rate effect (IDRE), low dose hyper-radiosensitivity (HRS).

Examples will be provided.

Biological aspects of hadrontherapy

Marjan Moreels, Sarah Baatout
Radiobiology Unit, Belgian Nuclear Research Centre, SCK•CEN, Mol, Belgium

Abstract

Recent advances in radiotherapy, such as hadron therapy, have been added as a radiation treatment choice for specific types of cancer. Hadron therapy uses beams of accelerated charged particles such as carbon ions to hit the tumor. Compared to conventional X-ray therapy, the energy deposited by charged particles at a certain penetration depth is inversely proportional to the ion's energy, forming a high-dose region at the end of the particle range, known as Bragg peak. This high ballistic accuracy allows depositing the maximal dose to the tumor, in combination with a reduced integral dose to normal tissue. Besides this physical advantage, charged particles have a higher biological effectiveness characterized by enhanced ionization density along their trajectories thereby inducing a greater number and more complex DNA lesions. As a consequence, they inactivate cells more effectively with less cell-cycle and oxygen dependence than conventional photons. This accounts for the highly lethal effects, even on radioresistant (with respect to X-rays) tumors. Further potential biological advantages of heavy ion therapy include suppression of tumor angiogenesis and metastasis.

In this presentation the current knowledge of the biological effects of heavy-ion irradiation is reviewed. In addition, projects in the field of hadron therapy that are currently ongoing at the Radiobiology Unit of SCK•CEN are introduced. Studies that aim to further investigate the differences in the radiobiology of ion beams from the conventional photon radiobiology should be strongly encouraged for the benefit of cancer patients. In this context, both *in vitro* and *in vivo* experiments can be useful to reduce existing uncertainties associated with particle beams including risk of late effects, and to improve the therapeutic efficacy.

Acknowledgements.
This work is partly supported by the Belgian Cancer Plan, Belgian Ministry of Public Health (CO-90-2088-01) as well as by the ESA/ BELSPO MOSAIC2 contract (42-000-90-380).

Investigation of low dose hypersensitivity mechanisms following irradiation with charged particles

Anne-Catherine Heuskin[1], Anne-Catherine Wera[1], Hélène Riquier[2], Carine Michiels[2], Stéphane Lucas[1]

[1]LARN – PMR, NARILIS, University of Namur – FUNDP, Belgium
[2]URBC-NARILIS, University of Namur – FUNDP, Belgium

Abstract

OBJECTIVES: To determine the survival fraction at low doses of A549 lung adenocarcinoma cells following irradiation with protons and alpha particles and investigate what type of linear energy transfer (LET) dependence for the hypersensitivity parameters of the Induced Repair model can be observed.

METHODS: A549 cells were irradiated with a broad beam of either 10 keV/µm, 25 keV/µm protons or 100 keV/µm alphas for clonogenic assays and phospho-histone H3 staining. The doses tested were in the 0.01-0.5 Gy range. The assessment of survival fraction of unirradiated A549 cells co-cultured with irradiated cells was also undertaken. Cell size was determined for the evaluation of a possible bystander contribution.

RESULTS: A549 cells were shown to exhibit low dose hypersensitivity (HRS) both for protons and alpha particles. The dose threshold at which HRS occurs is shown to decrease with increasing LET, whereas α_s, the initial slope of the survival curve, increases with increasing LET. However, the enhanced cell killing evidenced after irradiation with alpha particles is likely to be attributed to bystander effect, due to the cell size and the reduced proportion of hit cells at very low doses. Consequently the dose profile of the bystander contribution in cell-killing could be extracted. Co-culture experiments plead in favor of a gap junction-mediated bystander signal.

CONCLUSION: Induced radioresistance is likely to be triggered after a certain amount of energy has been deposited in the cell, and therefore may be dependent on LET. This study also shows that bystander effect and low dose hypersensitivity may co-exist for a given cell line following irradiation with charged particles and that both impact on the shape of the survival curve.

Influence of carbon ion radiation on metastasis related genes in human prostate cancer cells

Annelies Suetens [1], Marjan Moreels[1], Vincent Grégoire[2], Sarah Baatout[1]
[1]Radiobiology Unit, Belgian Nuclear Research Centre, SCK•CEN, Mol, Belgium
[2] Center for Molecular Imaging and Experimental Radiotherapy, UCL Saint-Luc Hospital, Brussels, Belgium

Abstract

Hadrontherapy is a form of external radiation therapy, which uses beams of charged particles such as carbon ions. Compared to conventional X-ray therapy, the main advantage of hadrontherapy is the precise dose localization along with an increased biological effectiveness. First results obtained from prostate cancer patients treated with carbon ion therapy, show good local tumor control and survival rates. However, the impact of hadrontherapy on cancer metastasis is not well characterized yet. Previous studies show that hadrontherapy may inhibit metastasis by suppressing cell motility and migration. In contrast, clinical studies show evidence that X-rays might promote the metastatic potential of cancer cells. In the present study we investigated the effect of carbon and X-irradiation on changes in metastasis related genes in a human prostate adenomacarcinoma cell line, PC3.

PC3 cells were irradiated with various doses (0, 0.5, 1 and 2 Gy) of accelerated ^{13}C-ions (75 MeV/u; LET = 33.4 keV/µm) at the GANIL facility (France). A similar experiment with X-rays (Pantak HF420 RX machine; 250 keV, 15 mA; dose rate= 0,25 Gy/min) was performed at SCK•CEN. RNA was extracted 2 h, 8 h and 24 h after irradiation. Samples irradiated with 0, 0.5 and 2 Gy (carbon ions and X-rays) were selected for further whole genome transcriptomic analysis using micro-arrays (8 h time-point). After labeling samples were hybridized to Human Gene 1.0 ST Array chips (Affymetrix). Gene expression profiles were analyzed using Partek software. Our initial results demonstrate that carbon irradiation induced more strongly effects at the level of gene expression compared to similar doses of X-rays. For instance, within a set of genes related to cell motility and migration we found seven genes (APC, NEXN, MYH10, CCDC88A, ROCK1, FN1 and MYH9) with a significant fold change of < -3 after 2 Gy of carbon ion irradiation which were not as strongly affected by X-rays. Although these findings need further validation, they seem to support the abovementioned data concerning the potential inhibitory effect of carbon ion therapy on cancer metastasis. A better understanding of the effects of different radiation qualities on the migration potential of prostate cancer cells is important for improving the clinical outcome of cancer radiation therapy.

Acknowledgements:
This work is partly supported by the Belgian Cancer Plan, Belgian Ministry of Public Health (CO-90-2088-01)

Survival fraction simulation code for in-vitro hadrontherapy and potential extension to treatment planning software

Anne-Catherine Heuskin[1], Anne-Catherine Wera[1], Hélène Riquier[2], Carine Michiels[2], Stéphane Lucas[1]

[1]LARN – PMR, NARILIS, University of Namur – FUNDP, Belgium
[2]URBC-NARILIS, University of Namur – FUNDP, Belgium

Abstract

OBJECTIVES: To develop a Monte-Carlo based computer program able to predict the survival fraction of cells irradiated *in vitro* with a beam of high linear energy transfer (LET) particles.

METHODS: We describe here the current status of a predictive Monte Carlo code that models the *in vitro* irradiation of a cell monolayer with a monoenergetic broad beam of charged particles. Three cases are studied: the usual high dose response, the bystander effect and the low dose hypersensitivity (HRS). The program first models the broad beam irradiation and double strand breaks (DSB) are distributed among the cell population. Cells progress through the cell cycle and are allowed to repair, with a kinetic specific to each phase. For high doses, the G_2 accumulation is triggered, allowing more time to repair, whereas for the low dose HRS region, the G_2 checkpoint is bypassed and cells undergo mitosis. Bystander effect is confined to non-hit cells only and is assessed using a dose-dependent probability.

Physical and biological inputs, such as linear energy transfer, yield of double strand breaks (DSBs) or p-H2AX and G_2 checkpoint kinetics are needed. Specific parameters related to low dose effects are required, such as cell and nucleus sizes, p-histone H3 kinetics or proportion of cells in the different phases of the cell cycle. Input parameters were determined for A549 lung adenocarcinoma cells following irradiation with 10 keV/µm protons, 25 keV/µm protons and 100 keV/µm alpha particles.

RESULTS: Preliminary results of our simulations are presented and compared with experimental data obtained for A549 cells irradiated with 10 keV/µm protons, 25 keV/µm protons and 100 keV/µm alphas particles.

CONCLUSION: First results are very encouraging. However, the biological basis of the bystander effect implementation should be further investigated.

Microdosimetric characterization of a therapeutic charged particle beam

Sabina Chiriotti[1,2], Paolo Colautti[3], Davide Moro[3], Emiliano D'Agostino[1], Edmond Sterpin[2] and Stefaan Vynckier[2,4]

[1]Belgian Nuclear Research Centre (SCK•CEN) Mol, Belgium
[2]IREC / MIRO Université Catholique de Louvain (UCL), Brussels Belgium
[3]INFN Laboratori Nazionali di Legnaro, Legnaro, Padova, Italy
[4]Cliniques univ. St-Luc, Université Catholique de Louvain, Brussels, Belgium

Abstract

Hadron therapy is a promising technique for some kinds of tumours due to its physical and biological advantages over conventional radiotherapy. Due to the strong dependence of the linear energy transfer (LET) with energy for heavy charged particles, the radiation quality of the beam varies significantly with depth within the irradiated tissue. Accordingly, it is well-established that LET and the absorbed dose are insufficient to characterize the relative biological effectiveness (RBE) of the ion beams.

Therefore, a detailed description of the local energy distribution delivered in the tumour and in the surrounding healthy tissues, at the microscopic level, may contribute to the optimization of the treatment efficiency, as well as to an accurate assessment of the relative biological effectiveness of the particle beam and its variation with depth.

The complete description of fluctuations, inhomogeneities and the stochastic behaviour of the interaction between radiation and matter, namely energy depositions at the microdosimetric level, are referred as microdosimetry. The microdosimetric approach is a powerful tool to characterize a radiation field because the relative contribution from each type of particle to the total energy spectrum can be determined by measuring the energy deposition events in micron sized volumes of comparable size to the cell.

Tissue Equivalent Proportional Counters (TEPCs) are the main devices used to perform microdosimetric beam characterization. By changing the pressure of the gas in the detector, it is possible to simulate an interaction volume comparable to that of a cell (in the order of several micrometres). The size of the counter imposes some limitations on its performance in high intensity beams such as those found in radiotherapy units. Because of the large sensitivity volume of standard-sized TEPC, of a few cm in diameter, they cannot be used in therapeutic particle beams since, they would rapidly undergo to pile-up effects distorting the energy spectrum. One approach to cope with this issue is by using miniaturized TEPC.

The aim of this study is to analyse and evaluate the response of a mini TEPC to high-LET particles. This device [1], developed at the Laboratori Nazionali di Legnaro - Istituto Nazionale di Fisica Nucleare (LNL-INFN), is designed for performing Boron neutron caption therapy (BNCT) dosimetry. The TEPC consists of two identical miniature counters with a sensitive collecting volume of 0.6 mm^3, which only differ on the wall material. The

cathode of one TEPC is loaded with ^{10}B while the other one is a regular cathode made of A-150 in order to characterize the radiation in presence and absence of boron.
The experimental technique and tests performed recently in the neutron field generated at the nuclear reactor of the Laboratory of Applied Nuclear Energy (LENA) at Pavia University will be presented.

[1] D. Moro, P. Colautti, M. Lollo, J. Esposito, V. Conte, L. De Nardo, A. Ferretti, C. Ceballos, "BNCT dosimetry performed with a mini twin tissue-equivalent proportional counters (TEPC)," Applied Radiation and Isotopes **67**, S171-S174 (2009).

Study of the effects of X-ray and alpha radiations on the interactions between tumor cells and endothelial cells: how to enhance their therapeutic efficacy

Hélène Riquier[1], Anne-Catherine Wera[2], Anne-Catherine Heuskin[2], Olivier Feron[3], Stéphane Lucas[2], Carine Michiels[1]

[1]URBC-NARILIS, University of Namur – FUNDP, Belgium
[2]LARN – PMR, NARILIS, University of Namur – FUNDP, Belgium
[3]FATH, University of Louvain – UCL, Belgium

Corresponding author

C. Michiels, URBC-NARILIS, FUNDP, 61 rue de Bruxelles, 5000 Namur, Belgium
Tel: +32 81724131
Fax: +32 81724135
E-mail: carine.michiels@fundp.ac.be

Abstract

BACKGROUND AND PURPOSE: Tumours are now considered as complex tissues including endothelial cells of the tumour vasculature, which can decrease radiotherapy efficacy. It is thus important to better characterize the response of both types of cells to irradiation. This study investigated the effects of X-ray and alpha particle irradiation on cancer and endothelial cells.

MATERIALS AND METHODS: A549 non-small-cell lung adenocarcinoma cells and human endothelial cells (EC) were exposed to X-rays or alpha particles. Responses were studied by clonogenic assays and nuclei staining. A gene expression study was performed by using Taqman low density array and the results were validated by qRT-PCR and ELISA.

RESULTS: The relative biological effectiveness of alpha particles was estimated to be 5.5 and 4.6 for 10% survival of A549 cells and EC respectively. Nuclei staining indicated that mitotic catastrophe was the main type of cell death induced by X-rays and alpha particles. Both ionizing radiations induced the overexpression of genes involved in cell growth, inflammation and angiogenesis.

CONCLUSIONS: Alpha particle irradiations are more effective than X-rays. The gene expression changes observed in both cell types after alpha particle or X-ray exposure showed possible crosstalk between both cell types that may induce the development of radioresistance.

Modulation of gene expression of endothelial cells in response to high LET nickel irradiation

Michaël Beck[1,2], Charlotte Rombouts[1,2], Marjan Moreels[1], An Aerts[1], Roel Quintens[1], Kevin Tabury[1], Arlette Michaux[1], Ann Janssen[1], Mieke Neefs[1], Eric Ernst[3], Birger Dieriks[2,4], Ryonfa Lee[5], Winnok H. De Vos[2,4], Charles Lambert[3], Patrick Van Oostveldt[2,4], Sarah Baatout[1]

[1]Radiobiology Unit, Belgian Nuclear Research Centre, SCK•CEN, Mol, Belgium ;
[2]Department for Molecular Biotechnology, Ghent University, Ghent, Belgium;
[3]Laboratory of Connective Tissues Biology, GIGA-Cancer, University of Liège, Liège, Belgium;
[4]NB-photonics, Ghent University, Ghent, Belgium;
[5]Biophysics Department, GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Accidental, medical and occupational exposures to ionizing radiation constitute a risk for the development of cardiovascular diseases. High Linear Energy Transfer (LET) radiation may elicit important effects on the cardiovascular system. However, the mechanisms of cardiovascular response to high LET radiation remain elusive. In the context of space exploration, astronauts performing a long-term journey would undergo cumulative doses of high LET radiation reaching the order of the Gray. The purpose of this study was to investigate the gene expression response of endothelial cells 8 h and 24 h after an irradiation with accelerated nickel ions (0.5, 2 or 5 Gy).

A 2 Gy nickel irradiation induced persistent DNA damage up to 24 h after treatment. Twenty four hours post irradiation, 5 Gy of nickel irradiation down-regulated of a multitude of genes involved in cell cycle and induced the expression of genes involved in cell cycle checkpoints. Our data show that the transcription factor E2F is likely to be involved in this process. We also report the up-regulation of genes involved in DNA damage response, oxidative stress, apoptosis and of cytokines, which are potentially linked to radiation-induced inflammation responses endothelial cells, possibly through the activation of NFκB.

Scientific output gathered during the phase 1 of the feasibility study 'Application of hadrontherapy in Belgium', part of action 30 of the FOD Belgian cancer plan.

SCK•CEN scientific output

Publications

2012

- Beck M., Rombouts C., Moreels M., Aerts A., Quintens R., Tabury K., Michaux A., Janssen A., Neefs M.,Ernst E., Diericks B., De Vos W., Lambert C., Van Oostveldt P., Baatout S. Modulation of gene expression of endothelial cells in response to high LET nickel irradiation.- (*in prep*)

- Rombouts C., Aerts A., Beck M., De Vos W.H., Van Oostveldt P., Benotmane R., Baatout S.- Comparison of the ionizing radiation response of primary HUVEC and the immortalized EA.hy926 cell line regarding DNA damage, apoptosis and cell cycle changes. - (*in prep*)

- Suetens A., Moreels M., Quintens R., d'Agostino E., Tabury K., Grégoire V., Gueulette J., Scalliet P., Vynckier S., Baatout S.- Influence of carbon ion radiation on metastasis related genes in human prostate cancer cells.- (*in prep*)

- Quintens R., Saeys Y., Janssen A., Michaux A., Tabury K., Benotmane MA., Baatout S.- Gene and exon expression signatures are useful biomarkers for low-dose ionizing radiation exposure. - (*in prep*).

Oral presentations

2012

- Moreels M.- Under the ray gun: impact of (cosmic) radiation on human health.- Stress-related Health Challenges in Space: from current knowledge to interdisciplinary countermeasures.- Munich, Germany, 27-30 March 2012.- *(Oral Presentation – invited speaker)*

- Quintens R.- Molecular and cellular mechanisms of ionising radiation.- Stress-related health challenges in Space: from current knowledge to interdisciplinary countermeasures.- Munich, Germany, 27-30 March 2012.- *(Oral Presentation – invited speaker)*

- Suetens A.- A contribution to the biological study of the response of prostate and colon cells to carbon ion irradiation.- Day of the PhDs.- Mol, Belgium, 27 April 2012.- *(Oral Presentation)*

- Rombouts C.- Cardiovascular effects related to low doses of ionizing radiation.- Day of the PhDs.- Mol, Belgium, 27 April 2012.- *(Oral Presentation)*

- Nascimento LF., D'Agostino E., De Deene Y.- On-line dosimetry for radiotherapy using non-invasive optical fiber sensors with Al2O3:C OSL detectors.- Day of the PhDs.- Mol, Belgium, 27 April 2012.- *(Oral Presentation)*

- Moreels M.- Carbon ion irradiation suppresses metastasis related genes in human prostate carcinoma cells. European Radiation Research Conference.- Naples, Italy, 15-19 October 2012. *(Oral Presentation)*

- Moreels M.- Carbon ion irradiation suppresses metastasis related genes in human prostate carcinoma cells. European Nuclear Conference.- Manchester, UK, 9-12 December 2012. *(Oral Presentation)*

- Rombouts C.- Characterization of the cellular response of HUVECs and EA.hy926 cells following exposure to low dose acute X-irradiation.- European Radiation Research Conference, Naples, Italy, 15-19 October 2012. *(Oral Presentation)*

- Nascimento LF.- Characterization of OSL Al2O3:C droplets for medical dosimetry. LUMDETR 2012 (International Conference on Luminescent Detectors and Transformers of Ionizing Radiation), Halle, Germany, September, 2012. *(Oral Presentation)*

Poster presentations

2011

- Rombouts C., Aerts A., Beck M., Tabury K., De Vos W., Benotmane R., e.a.- Biological and molecular mechanisms of vascular damage after low dose X-irradiation.- Symposium of CARDIORISK.- Munich, Germany, 7-7 June 2011.- *(Poster Presentation)*

- Rombouts C., Aerts A., Beck M., Tabury K., De Vos W., Benotmane R., e.a.- Assessment of DNA damage, apoptosis and cell cycle changes in endothelial cells after low dose X-irradiation.- 14th International Congress of Radiation Research .- Warsaw, Poland, 28 August - 1 September 2011.- *(Poster Presentation)*

- Suetens A., Moreels M., Tabury K., D'Agostino E., Baatout S.- Biological effects induced by low-LET radiation in human prostate and colon carcinoma cell lines: Experimental basis for future experiments with carbon ions.- NanoIBCT.- Caen, France, 2-6 October 2011.- *(Poster Presentation)*.

- Moreels M., Quintens R., De Vos W., Beck M., Tabury K., Suetens A., e.a.- Molecular and cellular changes in human endothelial cells in response to nickel ion irradiation.- NanoIBCT.- Caen, France, 2-6 October 2011.- *(Poster Presentation)*.

- Rombouts C., Aerts A., Beck M., Tabury K., De Vos W., Benotmane R., e.a.- Non-cancer effects (and in particular cardiovascular effects) related to low doses of radiation.- Day of the PhDs- Mol, Belgium, 6 October 2011.- *(Poster Presentation)*.

- Rombouts C., Aerts A., Beck M., Tabury K., De Vos W., Benotmane R., e.a.- Low dose research on cardiovascular risks at SCKCEN.- Third MELODI Workshop.- Rome, Italy, 2-4 November 2011.- *(Poster Presentation)*

- Nascimento LF., Vanhavere F., D'Agostino E., De Deene Y.- "OSL dosimetry in C-ions using Al2O3:C micro crystals.- 2nd Joint Symposium on Carbon Ion Radiotherapy, Lyon, France (Organised by NIRS-ETOILE), November 2011.- *(Poster Presentation)*

2012

- Nascimento LF., Vanhavere F., D'Agostino E., De Deene Y.- OSL dosimetry using Al2O3:C micro crystals.- BHPA (Belgium Hospital Physicist Association) meeting, Brussels – Feb 10-11 2012

- Moreels M., Quintens R., De Vos W., Beck M., Tabury K., Suetens A., e.a.- Molecular and cellular changes in human endothelial cells in response to nickel ion irradiation.- Radiation Science in the Netherlands.- Noordwijkerhout, Netherlands, 19 April 2012.- *(Poster Presentation)*

- Suetens A., Moreels M., Tabury K., D'Agostino E., Baatout S.- Biological effects induced by low-LET radiation in human prostate and colon carcinoma cell lines.- Radiation Science in the Netherlands 2nd symposium.- Noordwijkerhout, Netherlands, 19-20 April 2012.- *(Poster Presentation)*

- Rombouts C., Aerts A., Beck M., Tabury K., De Vos W., Benotmane R., e.a.- The endothelium response to low dose ionizing radiation.- Radiation Science in the Netherlands, 2nd Symposium.- Noordwijkerhout, Netherlands, 19-20 April 2012.- *(Poster Presentation)*

- Moreels M., Quintens R., De Vos W., Beck M., Tabury K., Suetens A., e.a.- Molecular and cellular changes in human endothelial cells in response to nickel ion irradiation.- Life in Space for Life on Earth Conference 2012, Aberdeen, UK, 17-22 June 2012.- *(Poster Presentation)*

- Quintens R, Moreels M, Tabury K, Baatout.- IBER-3 project – Gene expression and cYtokine Monitoring for Biodosimetry and RAdiation Sensitivity Screening (GYMBRASS) -

Life in Space for Life on Earth Conference 2012, Aberdeen, UK, 17-22 June 2012.- *(Poster Presentation)*

- Nascimento LF, Vanhavere F, D'Agostino E, Defraene G, De Deene Y. Characterization of OSL AL2O3:C droplets for medical dosimetry. WC2012 (World Congress 2012 Medical Physics and Biomedical Engineering) meeting, Beijing, China. May 26-June 01 2012. *(Poster Presentation)*

- Suetens A., Moreels M., Quintens R., d'Agostino E., Tabury K., Baatout S.- Healthy tissue sensitivity after hadrontherapy. - The Fourth International MELODI Workshop.- Helsinki, Finland, 12-14 September 2012.

– Education and training

2012

- Suetens A.- *In vitro* and *in vivo* models for hadrontherapy.-.- Mol, Belgium, 5-16 March 2012.- (European Master in Radiobiology). *(International course)*

- Moreels M.- Introduction to hadrontherapy: biological and clinical aspects.- SCK•CEN, Mol, Belgium, March, 2012.- (European Master in Radiobiology). *(International course)*

- Promoted work: Bachelor/Master/PhD thesis

2012

- Beck M.- Molecular mechanisms related to DNA damage, apoptosis and inflammation in fibroblasts and endothelial cells subjected to space simulated conditions.- PhD thesis defense.- Ghent, Belgium, 4 May 2012. (*PhD thesis*)

- Maximililian J. – Impact of hadrontherapy on metastasis. - SCK•CEN, Mol, Belgium (October 2012-February 2013). Supervisor: Moreels M. *(Internship)*

- Internal reports

2012

- S. Chiriotti, E. D'Agostino, F. Vanhavere, E. Sterpin, and S. Vynckier. Neutron characterization with a TEPC. Internal report. January 2012

- S. Chiriotti, E. D'Agostino, E. Sterpin, P. Colautti, S. Agosteo and S. Vynckier. Microdosimetry of hadron beams: state of the art. Submitted to 27th Annual Symposium of the Belgian Hospital Physicists Association (BHPA), February 2012

- S. Chiriotti, P. Colautti, D. Moro. Measurement of the test-input capacity. Internal report, March 2012

- S. Chiriotti, P. Colautti, D. Moro. Measurements of the gas gain in a TEPC. Internal report, March 2012

- S. Chiriotti, Project Report - Microdosimetry course at the Karolinska Institute. Under progress. July 2012

FUNDP scientific output

Publications

2011

- Heuskin AC, Wéra AC, Riquier H, Michiels C, Bulgheroni A, Jastrzab M, Caccia M, Lucas S. "*On the comparison of three methods of assessing beam quality for broad beam in vitro cell irradiation*". *Nuclear Instruments and Methods in Physics Research B, 269(24): 3132-3136, (2011).*
- Wéra AC, Riquier H, Heuskin AC, Michiels C, Lucas. "*In vitro irradiation station for broad beam radiobiological experiment*" in *Nuclear Instrument and Methods in Physics Research B, 269: 3120-3124, (2011)*

2012

- Riquier H, Wéra AC, Heuskin AC, Feron O, Lucas S, Michiels C. "*Comparison of X-ray and alpha particle effects on a human cancer and endothelial cells: survival curves and gene expression* profiles." Radiotherapy and Oncology. Revised manuscript submitted on 12th May 2012.
- Heuskin AC, Wéra AC, Riquier H, Michiels C, Lucas S. *"Low dose hypersensitivity following in vitro charged particle irradiations: literature review and proposed mechanism*" (*submitted to* International *Journal of Radiation Biology)*
- Heuskin AC, Wéra AC, Riquier H, Michiels C, Lucas S. *"Hadrontherapy: Toward Computer Simulation of Survival Curves* (*in prep)"*
- Heuskin AC, Wéra AC, Riquier H, Michiels C, Lucas S. *"Low dose hypersensitivity of A549 cells following irradiation with protons and alpha particles and threshold dose assessment (in prep)"*
- Wéra AC, Heuskin AC, Riquier H, Michiels C, Lucas S. *"Low LET proton irradiation of A549 non-small cell lung adenocarcinoma cells: dose response and RBE determination" Submitted to Radiation Research*

Oral presentations

2011

- miRNA and cancer. Invited speaker. FNRS-Ecole doctorale thématique en cancérologie expérimentale. Facultés Universitaires Notre-Dame de la Paix, Namur, Belgique - 13th September 2011. "*Comparison of X-ray and alpha particle irradiations on survival fraction and gene expression pattern in human lung adenocarcinoma A549 cells and endothelial cells"*

2012

- Séminaire Life-Science. Facultés Universitaires Notre-Dame de la Paix, Namur, Belgique – 24th April 2012.

"*Comparison of X-ray and alpha particle irradiations on survival fraction and gene expression pattern in human lung adenocarcinoma A549 cells and endothelial cells*"

Poster presentations

2011

- Séminaire des jeunes chercheurs Télévie 2012. Université Libre de Bruxelles - Erasme, Belgique – 1st December 2011. Riquier H., Wéra A.-C., Heuskin A.-C., Feron O., Lucas S., Michiels C. "*Comparison of X-ray and alpha particle effects on a human cancer and endothelial cells: survival curves and gene expression*"
- miRNA and cancer. Facultés Universitaires Notre-Dame de la Paix, Namur, Belgique - 13th September 2011. Riquier H., Wéra A.-C., Heuskin A.-C., Feron O., Lucas S., Michiels C. "*Comparison of X-ray and alpha particle irradiation effects on human lung carcinoma A549 cells*"

2012

- The role of imaging in cancer research (BACR 2012). UZ Brussel – Université Libre de Bruxelles, Belgique - 4th February 2012. Riquier H., Wéra A.-C., Heuskin A.-C., Feron O., Lucas S., Michiels C. "*Comparison of X-ray and alpha particle effects on a human cancer and endothelial cells: survival curves and gene expression*",
- Heuskin AC, Wéra AC, Riquier H, Michiels C, S. A. Marino, Lucas S. On the need to perform microbeam cell irradiations to get useful data for the development of a predictive Monte Carlo code of survival fraction.*10th International Workshop: Microbeam Probes of Cellular Radiation Response, New York,*
- Heuskin AC, Wéra AC, Riquier H, Michiels C, S. A. Marino, Lucas S. On the need to perform microbeam cell *irradiations* to get useful data for the development of a predictive Monte Carlo code of survival fraction. *10th réunion du groupe de contact FNRS "Stress oxydant": Oxidative stress and genotoxic response, Mons,*

Bachelor/Master/PhD thesis

2012

- Abel D. – Radioresistance caused by molecular communication between tumor cells and endothelial cells after proton irradiation. URBC-NARILIS, University of Namur – FUNDP and LARN – PMR, NARILIS, University of Namur – FUNDP, Belgium. (February 2012 until now). Master report. Supervisor: Riquier H.

- Peereboom N. - Characterisation of a broad carbon ion beam for in vitro cell irradiations: Feasibility study and first biological analyses – FUNDP, Belgium, June 2012, Supervisor: Prof. S. Lucas