COURSE 1

Measuring radiation-induced DNA damage, DNA repair and cell death: radiation biology in lab practice

The course was organised by **Stockholms Universitet (Stockholm University) (SU)**, between **17 and 21 October 2022**, and aimed to acquaint the participants with the state-of-the-art cellular effects of ionising radiation which are relevant for the broader field of radiation research. The course had two parts: theoretical and practical. The theoretical part, designed for non-biologists,



focused on SINFONIA-relevant aspects of biological effects of ionising radiation as well as on techniques to detect them using cytogenetics and immunogenetics.



The practical part focused on teaching the classical laboratory techniques used to study cellular effects of radiation in cells: the clonogenic cell survival test, analysing chromosomal aberrations by the Giemsa methods and in-situ hybridization with whole chromosome probes, as well as the gamma H2AX focus assay. Participants learned how the techniques are carried out and how samples are analysed. Every student had a microscope at their disposal to analyse slides for chromosomal

aberrations and micronuclei. Painted chromosomes and gammaH2AX foci were analysed on computer images.

The course was attended by 5 persons, 3 master students and 2 researchers from Poland (Jan Kochanowski University in Kielce) and Norway (Norwegian University of Life Science in Aas), respectively. Overall, the participants were satisfied with the course, especially with the practical exercises which were rated the highest score in the survey conducted at the end of the training.



A participation diploma with 1.5 ECTS credit points (corresponding to one week of education at Stockholm University) was awarded to all participants.







Day	Time	Lecture				
Monday	09:00 - 10:15	Lecture: Radiation-induced DNA damage, repair and cell death,				
17 October		Lecturer: Andrzej Wojcik				
	10:30 - 12:00	Guided tour of radiation exposure facilities installed at the Stockholm				
		University.				
		Analysis of clonogenic cell survival results.				
	13:30 - 17:00	Group 1: Lab: clonogenic cell survival – practical work				
		Group 2: Lab: chromosomal aberrations – practical work				
Tuesday	09:00 - 10:15	Lecture: Radiation-induced chromosomal aberrations and				
18 October		micronuclei, Lecturer: Prabodha Kumar Meher				
	10:30 - 12:00	Microscopic analysis of chromosomal aberrations				
	13:30 - 17:00	Group 1: Lab: chromosomal aberrations – practical work Group 2:				
		Lab: clonogenic cells survival – practical work				
Wednesday 19	09:00 - 10:15	Lecture: Factors influencing cellular radiosensitivity, <i>Lecturer: Lovisa</i>				
October		Lundholm				
	10:30 - 12:00	Microscopic analysis of micronuclei				
	13:30 - 17:00	Group 1: Lab: Fluorescence in situ hybridisation				
		Group 2: lab: DNA repair gamma H2AX foci				
Thursday	09:00 - 10:15	Lecture: Individual sensitivity to radiation – biomarkers and				
20 October		implications for radiological protection, Lecturer: Andrzej Wojcik				
	10:30 - 12:00	Analysis of gammaH2AX foci and aberrations after fluorescence in-				
		situ hybridisation				
	13:30 - 17:00	Group 1: Lab: DNA repair gamma H2AX foci				
		Group 2: lab: Fluorescence in situ hybridisation				
Friday	09:00 - 11:30	Presentations of analysed results and general discussion				
21 October	11:30 - 13:00	Common lunch and end of course				





COURSE 2

Patient dosimetry and occupational radiation exposure assessment arising from Lu-177, Ga-68, I-131 and Y-90 procedures

The course was organised by Servicio Gallego de Salud (Galician Healthcare Service) (SERGAS) and aimed to provide an overview of several nuclear medicine procedures and their related dosimetry and shielding considerations towards four main isotopes: Lu-177, I-131, Ga-68 and Y-90. The course had two parts: an online pre-session (19-21 September 2022) and on-site course held at the Meixoeiro Hospital in Vigo Spain between 28 and 30 September 2022.





In the **online pre-course**, the participants learned about the **fundamentals of the different radiopharmaceuticals** used in nuclear medicine and interventional radiology, the different **dosimetry methods and tools** available and under research, and **the basics of radiation protection** when working with these radioisotopes. The **on-site** part offered both **theoretical and practical sessions** in which the participants were taught about different **medicine planning and dosimetry software** as well as about

various radiological protection protocols carried out at the Meixoeiro hospital.



The course was attended by **29 participants from 6 countries** (Belgium, The Netherlands, Poland, Portugal, Spain, Switzerland) with diverse backgrounds – ranging from computational scientists to nuclear medicine technologists and medical physicists – and level of experience (both students and senior professionals).





Day	Time	Lecture				
ONLINE		·				
Monday	16:00 - 17:00	Fundamentals of I-131 treatments in Nuclear Medicine, Lecturer:				
19 September		Ismini Mainta (HUG)				
	17:00 - 18:00	Fundamentals of Y-90 treatments in Nuclear Medicine, <i>Lecturer</i> :				
		Nicola Bianchetto Wolf (HUG)				
	18:00 - 19:00	Fundamentals of Theranostics with Lu-177/Ga-68 in Nuclear				
<u> </u>		Medicine, <i>Lecturer: Valeria del Valle (SERGAS)</i> .				
Tuesday 20 September	16:00 - 17:00	computational models for nuclear medicine dosimetry calculations, <i>Lecturer: Habib Zaidi (HUG)</i>				
	17:00 - 18:00	Dose calculation in patients treated with Y90, Lecturers: Azadeh Akhavanallaf and Yazdan Salimi (HUG)				
	18:00 - 19:00	Overview of treatment planning system in nuclear medicine, <i>Lecturer: Manuel Bardiès (IRCM)</i>				
Wednesday	16:00 - 17:00	Radiological protection basis, <i>Lecturer: Lara Struelens (SCK CEN)</i>				
21 September	17:00 - 18:00	Operational radiological protection applied to nuclear medicine, Lecturer: Jose Antonio Terrón León (Virgen de la Macarena Hospital)				
	18:00 - 19:00	Operational radiological protection applied to interventional radiology, <i>Lecturer: Roberto Sánchez Casanueva (Hospital Clínico San Carlos)</i>				
	19:00 - 20:00	Closing and Q&A session, <i>Lecturers: Antonio López Medina</i> (SERGAS), Mercedes Riveira Martín (FBGS)				
ON-SITE						
Wednesday	09:00 - 10:00	Y-90 for hepatic radioembolization treatments, Lecturer:				
28 September		Mercedes Riveira Martín (FBGS)				
	10:00 - 11:00	ose calculation of Y-90 radioembolization treatments, <i>Lecturer:</i> Manuel Sánchez García (USC University Hospital)				
	11:00 - 11:30	Break				
	11:30 - 12:30	I-131 for treatment of thyroids malignancies and alterations, Lecturer: Gadea Castillo (SERGAS)				
	12:30 - 13:30	Lu-177/Ga68 metabolism and basis of theranostics in neuroendocrine tumours (NET), <i>Lecturer: Antonio López Medina</i> (SERGAS)				
	13:30-14:30	Break				
	14:30 - 17:30	Practice*				
Thursday 29 September	09:00 - 10:00	Dose calculation of Lu-177 treatment, <i>Lecturer: Pablo Mínguez Gabiña (Cruces/Gurutzeta University Hospital)</i>				
	10:00 - 10:30	Break				
	10:30 - 11:30	Practical approaches for reduction of staff doses in Lu-177 treatments, <i>Lecturer: Pablo Mínguez Gabiña (Cruces/Gurutzeta</i> <i>University Hospital)</i>				
	11:30 - 12:30	Dose calculation in Ga-68 procedures, <i>Lecturer: Nerea Encina</i> Baranda (UCM)				
	12:30 - 13:30	Practical approaches for reduction of staff doses in Ga-68 procedures, Lecturer: José Antonio Terrón León (Virgen de la Macarena Hospital)				
	14:30 - 16:30	Practice*				
Friday	09:00 - 10:00	Dose calculation of I-131 treatment, <i>Lecturer: Alex Vergara Gil</i> (<i>Biomediga Group</i>)				



TRAINING PROGRAMME 2022



www.sinfonia-appraisal.eu/education/

30 September

10:00 - 11:00	Practical approaches for reduction of staff doses in I-131		
	treatments, Lecturer: Mercedes Riveira (FBGS)		
11:00 - 11:30	Break		
11:30 - 12:30	Practical approaches for reduction of staff doses in Y-90		
	radioembolization treatments, Lecturer: José Antonio Terrón		
	León (Virgen de la Macarena Hospital)		
12:30 - 13:30	Closing seminar, Lecturers: Antonio López Medina and all		
	lecturers		

For the **practice sessions** the students were divided into six groups:

Practice		28/09/2022			29/09/2022	
		15:30	16:30	14:30	15:30	
		-	-	-	-	
		16:30	17:30	15:30	16:30	
Practice 1: Dose rate monitoring and shielding considerations in Lu-177 and I-131 treatments. Optimisation with real time monitoring (Mercedes Riveira)	G1	G5	G4	G2	G3	
Practice 2: Dosimetry calculation with SimplicitY90 (Boston Scientific)	G3	G1	G5	G4	G2	
Practice 3: Dose rate monitoring and shielding considerations in Ga-68 diagnostic procedures. Optimisation with real time monitoring (Isaac Sánchez Díaz)	G2	G3	G1	G5	G4	
Practice 4: Dosimetry calculation with MIM	G4	G2	G3	G1	G5	
Practice 5: Dosimetry calculation with PlanetDose (RaySafe)	G5	G4	G2	G3	G1	







COURSE 3

Running external beam radiotherapy on the virtual radiation therapy simulator (VERT)

The course was organised by Swietokrzyskie Centrum Onkologiisamodzielny Publiczny Zaklad Opiekizdrowotnej W Kielach (Holy Cross Cancer Centre) (SCO) between 26 and 30 September 2022 in Kielce, Poland, and aimed to introduce external beam radiotherapy. The course had two parts: theoretical, which presented the basis of radiotherapy, and a practical part. The learning outcome was to gain a deeper understanding of the principles of planning and performing radiotherapy, with special focus on dose distribution in organs and tissues and on possible consequences of dosimetric and patient positioning errors.

The practical sessions focused on the techniques employed in planning of therapeutic treatment for prostate and breast cancer patients. The participants created therapeutic plans on individual RayStation planning stations and observed their implementation using the VERT simulator. The effects of an incorrect treatment plan resulting from improper dosimetric control of the system or



incorrect positioning of the patient on the therapeutic table were thus observed and discussed.



score in the survey conducted at the end of the training.

The course was attended by 4 persons, 2 master students, 1 PhD student and 1 postdoctoral researcher from Poland (Warsaw University and Jan Kochanowski University in Kielce), Germany (Rostock University Medical Centre) and Sweden (Stockholm University), respectively. Overall, the participants were satisfied with the course, especially with the practical exercises which were rated the highest





Day	Time	Lecture
Monday	09:00 - 10:30	Lecture: Basic elements of radiotherapy, Lecturer: Piotr Kedzierawski
26 September	10:45 - 12:15	Lecture: Introduction to VERT, Lecturer: Tomasz Kuszewski
	13:30 - 17:00	Simulation of prostate cancer therapy: delineation of tumour,
		creating a therapy plan using Ray Search stations, <i>Instructor: Tomasz</i>
		Kuszewski
Tuesday	09:00 - 10:30	Lecture: Overview of radiotherapy techniques, Lecturer: Katarzyna
27 September		Wnuk
	10:45 - 11:30	Lecture: Biological basis of radiotherapy and the problem of second
		primary cancers, Lecturer: Andrzej Wojcik
	13:00 - 15:00	Simulation of prostate cancer therapy: implementation and
		verification using, VERT, Instructor: Katarzyna Wnuk
Wednesday	09:00 - 10:30	Lecture: Cancer types and optimal cancer therapies, Lecture: Piotr
28 September		Kedzierawski
	10:45 - 12:15	Lecture: Radiation safety of the patient and the personnel, <i>Lecturer</i> :
		Agata Walęcka-Mazur
	13:30 - 17:00	Simulation of breast cancer therapy: delineation of tumour, creating
		a therapy plan using RaySearch stations, Instructor: Krzysztof Bulinski
Thursday	09:00 - 10:30	Lecture: Use of cancer biomarkers for therapy selection, Lecturer:
29 September		Artur Kowalik
	10:45 - 12:15	Lecture: Selection of optimal therapy for a patient and clinical
		routine, Lecturer: Jacek Sadowski
	13:30 - 17:00	Simulation of breast cancer therapy: implementation and verification
		using VERT, Instructor: Krzysztof Bulinski
Friday	09:00 - 11:30	Visit of the units PET, cancer biomarkers, medical physics and
30 September		radiotherapy at the Holy Cross Cancer Centre
	11:30 - 13:00	Common lunch and end of meeting





COURSE 4

Introduction to Machine Learning / Deep Learning

The course was organised Fundacion Publica Gallega Centro Tecnologico de Supercomputacion de Galicia (Galicia Supercomputer Centre) (CESGA) between 12 and 19 September 2022 in Santiago de Compostela, Spain, and aimed to teach the participants about the basic machine learning (ML) algorithms and their application to the SINFONIA related research topics.



The first four days of the course covered several concepts and techniques of machine learning such as – supervised, unsupervised and reinforcement learning, deep learning (DL) – as well as various algorithms including – classification, regression, support vector machines, decision trees, ensembles, random forest, AdaBoost / XGBoost, naive bayes; in addition, the participants were advised on

advanced computational techniques to accelerate the training of models using high performance computing (HPC) solutions and how to optimise the selection of models' architecture and hyperparameters by means of search algorithms. The last day of the course was dedicated to practical examples of how machine learning algorithms are used in improving imagining procedures and thus minimise the radiation exposure of patients. The first example on nuclear medicine was presented by Prof. Habib Zaidi, while Prof. John Damilakis presented examples related to dosimetry for X-ray imaging procedures.

The course was attended by **31 persons from 5 countries** (Belgium, Czech Republic, Germany, Spain and Sweden) representing the SINFONIA project partners, but also external institutions such as University of Santiago de Compostela (Spain), University Hospital of Hamburg (Germany) and University Hospital Olomuc (Czech Republic).



Overall, the participants were satisfied with the course, 23 out of 24 respondents answered that the course met their expectations.



TRAINING PROGRAMME 2022



www.sinfonia-appraisal.eu/education/



Mercedes Riveira-Martin, participant: "I believe that all the requirements for a complete, valid, and interesting course have been met. First, the platform where the course materials were hosted is a good tool that has facilitated the work of the students. The structure of the course has been planned with a lot of sense, covering from more general and basic concepts, such as the definition of a neural network, to more complex models and techniques, such as reinforcement learning. In addition, each session had a practical part, in which the teacher developed in detail a practical example of the application of ML techniques programmed in Python, which is very useful. The level of mathematics was sufficient to understand the fundamentals of machine learning from a scientific perspective. In addition, the level of knowledge of the teachers in the subject facilitated the explanations, as they knew perfectly well what they were talking about. The room in which the classes were held was comfortable, with enough ventilation, light, and space to be able to stay quietly for five hours. A coffee break with food and drink was also available, which was much appreciated. Finally, the last day's sessions, given by professors John Damilakis and Habib Zaidi, were a perfect ending, showing ML applications directly related to the field of medical physics and the SINFONIA project. Overall, it has been an intense, interesting, practical, and useful course for the work applying machine learning techniques."





Day	Lecture					
Monday	Introduction to neural networks (5h),					
12 September	Lecturer: Andrés Gómez Tato, PhD (Head of Applications and Projects					
	Department, CESGA)					
	 Basic concepts 					
	 Methodology of Machine Learning projects 					
	 Classification and regression 					
	 Supervised training 					
	 More frequent APIs 					
Tuesday	Deep Learning (5h),					
13 September	Lecturer: Andrés Gómez Tato, PhD (Head of Applications and Projects					
-	Department, CESGA)					
	 Convolutional networks and deep networks. 					
	 Networks for temporal analysis: RNN / LSTM. / GRU 					
	 Transfer Learning 					
	 Autoencoders 					
Wednesday	Other algorithms I (5h),					
14 September	Lecturer: Andrés Gómez Tato, PhD (Head of Applications and Projects					
	Department, CESGA)					
	 Support Vector Machines 					
	 Decision trees 					
	 Ensembles 					
	 Random Forest 					
	 AdaBoost / XGBoost 					
	Naive Bayes					
	Clustering					
	Lecturer: Jorge Fernández Fabeiro, PhD (SINFONIA Project Senior Technician,					
	CESGA)					
	 Basic concepts 					
	 Unsupervised training 					
	 K-means / K-Modes / K-Prototypes 					
Thursday	Other algorithms II: Advanced computational techniques (5h),					
15 September	Lecturer: José Carlos Mouriño Gallego, PhD (SINFONIA WP5 Leader –					
	Applications Senior Technician, CESGA)					
	Reinforcement learning					
	Lecturer: Jorge Fernández Fabeiro, PhD (SINFONIA Project Senior Technician,					
	CESGA)					
	 Parallel training 					
	Best architecture and parametric search					
	Guided tour to Finis Terrae III supercomputer facilities (CESGA Technical Staff)					
Friday	Machine learning and exposure to ionizing radiation from medical imaging					
16 September	procedures (5h)					
	Machine learning in Nuclear Medicine					
	Lecturer: Prof Habib Zaidi (Geneva University Hospital, Geneva, Switzerland)					
	Viachine learning in X-ray imaging					
	Lecturer: Proj. John Damilakis (SINFUNIA Scientific Leader – School of Medicine,					
	University of Crete, Greece)					

