RIGA TECHNICAL UNIVERSITY

Faculty:	RTU Center of High-Energy Physics and Accelerator Technologies
Institute (Department):	Service of the Vice-Rector for Research
Collaborating entity:	European Center for Nuclear Research (CERN)

PLAN OF DOCTORAL THESES

Field:	Engineering sciences and technologies: Mechanical engineering and mechanics
Subfield:	Mechanical engineering technologies

Luca Piacentini

(Doctoral student's name and surname)

Title of Doctoral Theses

Mechanical integration of systems, instruments and components of a Carbon ion rotating gantry for medical treatments

Scientific advisor:	Prof. Dr. Toms Torims (RTU), Dr. Diego Perini (CERN), Head of the EN-MME design office Prof. Dr. Stefano Uberti (UNIBS)

(Name, Surname, Position, Scientific Degree)

Explanation of Doctoral Thesis:

Development of novel cancer treatment methods is one of the important activities of Accelerator Community and leading research laboratories like CERN. These new and promising technologies need scientifically based and rigorous systemic developments. The core idea of this PhD Thesis is to make tangible contribution to the integration of relevant systems, instruments and components of a carbon ion rotating gantry, such as: the driving system, the cryogenic fluid supply system, the electricity supply system, diagnostic instruments, cryostats and magnets, safety mechanisms and patient's dedicated structures. This doctoral thesis will include the study on the interaction between the systems, instruments and components and development of models and procedures to form a base knowledge that can be used for future applications.

Topicality of Theme:

Interest in Carbon ion particle treatments of cancer tissues is growing, due to the advantages of treating certain types of tumors with heavy ions [1]. This is related to the Bragg Peak [x] of the particle: in the case of carbon, most of the beam energy is delivered at a given depth in the tissues and very little doses are dissipated in the surrounding healthy tissues. The treatment is more effective when the beam is delivered at different angles with respect to the patient. Therefore, the machine needs to be able to rotate around the patient. At the moment, there are only a few facilities in the world able to rotate and deliver carbon beams [2]. These gantries are large structures, with counterweights to have a perfectly balanced axisymmetric element. The total weight is of the order of 600 tons, in the case of the HIT, Heidelberg structure [3], and 300 tons for HIMAC, Chiba which is a more recent facility [4]. A simplified gantry using bent superconducting magnets has been proposed [5]. Parallel to the development of new geometry of superconducting magnets, the development of innovative solutions for the mechanical rotating supporting structure and the integration of systems, instruments and components is necessary.

1. Ohno, T. Particle radiotherapy with carbon ion beams. EPMA Journal 2013, 4 (1), 1–7.
2. Particle therapy facilities in clinical operation. Available online: https://www.ptcog.ch/index.php/facilities-in-operation (accessed on 14 January 2021).
3. Fuchs, R.; Weinrich, U.; Sust, E. Assembly of the carbon beam gantry at the Heidelberg Ion Therapy (HIT) accelerator. Proceedings of EPAC-2008, Genoa, Italy, 2008.
4. Iwata, Y et al. Superconducting Gantry for Carbon-Ion Radiotherapy. Proc. 9th Int. Particle Conf.(IPAC'18), Vancouver, BC, Canada, April 29-May 4, 2018 (Int. Particle Conf. no 9), 1232–6.
5. Benedetto, E.; Harbi, N. A.; Brouwer, L.; Tommasini, D.; Prestemon, S.; Riboni, P.; Amaldi, U. A Carbon-Ion Superconducting Gantry and a Synchrotron Based on Canted Cosine Theta Magnets, 2021. arXiv preprint arXiv:2105.04205.

Scientific innovations and practical application:

Development of standard models and procedures regarding the integration and interaction between systems, instruments and components will be made. This thesis will have multidisciplinary approach that will cover the following topics:

- Mechanical design: finite element analysis (FEA) of the structure, choice and optimization of the driving and control systems.

- Thermodynamics: design of the cryogenic system.
- Logistics: routing of pipes and cables, study of the positioning of platforms and cranes for maintenance.
- Treatment related studies: positioning of built-in imaging tools and the patient movement robotic arm.

These subjects are somehow known, if taken separately, however, this thesis proposes to adopt an holistic approach in the framework of the Mechanical integration of systems, instruments and components of Carbon ion rotating gantry. This will create the know-how that can be exported and shared between the European nations and industries, to enhance patient's possibility to benefit from more efficient facilities. Such facilities will also be more affordable for local institutions. The aforementioned will give significant contribution to the development of medical particle accelerators and will be a novel contribution to Mechanical engineering technologies. In particular this will benefit the field of Carbon-ion and hadron therapy machines.

Scientific advisors:

Prof. Dr. Toms Torims

Dr. Diego Perini

Prof. Dr. Stefano Uberti

(signatures)

Planned funding for the doctoral student's employment in a research project related to the topic of doctoral theses (planned financial support for business trips and publications)

Planned financial support	EUR
Salary	22500
Business trips	3000
Publications	500

Head of the structural unit: _____(signature) Dr. Kārlis Dreimanis, Director of the Center of High Energy Physics and Accelerator technology

Doctoral student's Name, Surname: Luca Piacentini

Faculty, institute of RTU: Center of High-Energy Physics and Accelerator Technologies

Plan of Doctoral thesis and it's implementation for the 1st study year

From October, 2021 until October, 2022.

1. EXAMS		
No.	**Subjects (course code, name of the course, CP)**	**Semester**
1.	Acceleretor Technologies, 8	*2nd*
2.	Particle Detectors, 2	*1st*
3.	Computing and Programming for Physics, 2	*1st*
4.	Statistical Methods in Data Analysis, 2	*1st*

5.	Radiation Safety, 1	*2nd*
6.	Introduction to Particle Physics, 2	*1st*
7.	Mathematics for Particle Physics, 4	*1st*
8.	Relativity and Cosmology, 4	*2nd*
9.	Research work, 23	*1st-2nd*
Total	48	

2. PLANNED PARTICIPATION IN CONFERENCES

NO.	Name, location, time	Information about performance
1.	Participation with oral presentation in at least one international conferences, seminars or major project meetings (e.g NIMMS, IPAC, HITRIplus)	
2.		

Doctoral student _____ 22. 10. 2021

Scientific advisor _____ ___. ___. 20___

Collegial Feedback from the Scientific advisors about the performed plan:

Scientific advisors

Prof. Dr. Toms Torims _____ ___. ___. 20___

Dr. Diego Perini _____ ___. ___. ___

Prof. Dr. Stefano Uberti _____ ___. ___. ___

Doctoral student _____ Certified with _____

By the Study Program Council _____ _____ decision (protocol No. _____).

Director of Center of High Energy Physics and Accelerator Technologies _____