PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Francesco Giordano

XXXIII Cycle

Training and Research Activities Report – First Year

Tutor: Prof. Pasquale Arpaia – co-Tutor: Dr. Benoit Salvant (CERN)

1. Information

a. Francesco Giordano, Master degree in Electronic Engineering – Università di Napoli Federico II, Impact of filling scheme on beam induced RF heating in CERN LHC and HL-LHC.
b. XXXIII Cycle- ITEE – Università di Napoli Federico II
c. PhD student enrolled at the PhD student programme at CERN
d. Tutor: Prof. Pasquale Arpaia co-Tutor: Dr. Benoit Salvant

2. Study and training activities

a. Courses (credits in brackets)
   - "Relativity", provided by Prof. H. Henke. (1)
   - "Electro-magnetism", provided by Prof. H. Henke. (0.5)
   - "Particle Optics", provided by Prof. J.M. De Conto (1)
   - "Introduction to Accelerator Design and mini-workshop", provided by Prof. P. Bryant. (1)
   - "Injection/Extraction", provided by Dr. T. Perron. (0.5)
   - "Transverse Beam Dynamics", provided by Dr. A. Latina. (2)
   - "MADX", provided by Dr. G. Sterbini. (0.5)
   - "Cyclotrons", provided by Dr. B. Jacquot. (0.5)
   - "Longitudinal Beam Dynamics", provided by Dr. E. Metral and Dr. B. Salvant. (2)
   - "Linear Imperfections", provided by Dr. H. Bartosik. (1)
   - "Linacs", provided by Dr. J. B. Lallement. (0.5)
   - "Non-linear Effects", provided by Dr. H. Bartosik. (0.5)
   - "Synchrotron Radiation", provided by Prof. R. Bartolini. (0.5)
   - "Space Charge", provided by Prof. M. Migliorati. (0.5)
   - "Instabilities", provided by Prof. M. Migliorati. (1)
   - "Accelerator design workshop", provided by Prof. R. Bartolini (1)
   - "Python Hands-on Introduction", provided by Dr. Jacek Generowicz (6)
   - PhD school "Italo Gorini", organized by the Prof. Pasquale Arpaia and Prof. Stephan Russenschuck (10/09/2018 - 14/09/2018) (4).
b. Seminars
   - "Particle accelerators instruments of discovery in physics, European Projects Collaborative Accelerator R&D,accelerators", Maurizio Vretenar (0,4);
   - "Introduction to CERN" Philippe Lebrun 12/01/2018 (0,4);
   - "The CERN Accelerator Network", Reyes Alemany Fernandez (0,4);
   - "Superconducting magnet test hall and CERN Control Center", Philippe Lebrun (0,8);
   - "ESRF in Grenoble", Philippe Lebrun (0,8);
   - "LHC & Future High-Energy Circular Colliders", Frederick Bordry (CERN) (0,6);
   - "The neutrino physics programme", Alain Blondel (0,4);
   - "Free-Electron Lasers", Eduard Prat Costa (0,4);
   - "Future High-Energy Linear Colliders", Louis Rinolfi (0,4);
   - "Novel High Gradient Particle Accelerators", Ralph Wolfgang Assmann (0,4);
   - "Advanced Measurement Virtual Tools for Industrial Applications", provided by Yannik Degla, Anna Buccarelli (0,5).

3. Credits summary

	Credits year 1								Credits year 2							
		1	2	3	4	5	6			1	2	3	4	5	6	
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary
Modules	24	14	6			4		24	14		14					14
Seminars	5,5	5	0	0,5		0		5,5	5	0	5	0	0	0	0	5
Research	32	0	2	10	7	4	10	33	41	8	0	8	9	8	8	41
	62	19	8	11	7	8	10	63	60	8	19	8	9	8	8	60

4. Research activity

Title: Beam induced RF heating

The High-Luminosity Large Hadron Collider (HL-LHC) project aims at improving the performance of the LHC in order to increase the potential for particle physics discoveries after 2025 [1]. The target is a factor of 10 in luminosity beyond the LHC's design value [1]. In order to increase the luminosity also the particle intensity has to increase leading to strong electromagnetic (EM) fields generated by the beam [2].
The interaction of EM fields generated by a beam made of high energy particles with the surrounding accelerator devices causes the beam to lose energy, which is dissipated in the surrounding devices: this can be referred to as beam induced RF heating. Since the beam induced RF heating goes quadratically with the bunch intensity [3], it is one of the major limitations to increase ng the performance of the machine.

The major sources of heating in an high energy accelerator are: the particles lost on the wall [4], the electron cloud [5] and the beam--induced heating due to impedance [3]. In several scenarios the amount of power loss due to beam--induced heating is the major contribution to the total power loss.
Because in the machine there are other sources accounting for the total power loss, from now on, unless clearly specified, the word power loss will be referred to the power loss due to beam induced heating.

The quantity allowing to distinguish the beam induced heating from the other contributions to the total power loss is the longitudinal impedance [6] of the structure where the beam is traveling into.
The longitudinal impedance is a frequency--defined quantity that represents the interactions between the EM fields generated by the beam and the considered component of the accelerator. The impedance depends strongly on the material and on the geometry of the component of the machine. The beam induced heating team has to monitor that the temperature of each component inside the machine does not exceed dangerous values that could cause unexpected behaviour.

For each machine component such as collimators, kickers, magnets, etc, it is possible to measure the impedance with different tests on the component, based on Radio Frequency (RF) measurements, before installing them in the machine.

My research is focused in studying and minimizing the beam induced heating by EM simulation on accelerator components and python modelling of the power loss dissipated by impedance in the

machine. The first year has been focused on the heating produced from one beam and it has also been extended to the study of two beam inside the same component.

The main external collaboration on this research are: CERN and INFN.

5. Products

Conference papers:

- ANALYSIS ON THE MECHANICAL EFFECTS INDUCED BY BEAM IMPEDANCE HEATING ON THE HL-LHC TARGET DUMP INJECTION SEGMENTED (TDIS) ABSORBER . L. Teofili, F. Giordano et al. Proceedings of IPAC 2018.
- A MULTI-PHYSICS APPROACH TO SIMULATE THE RF-HEATING 3D POWER MAP INDUCED BY THE PROTON BEAM IN A BEAM INTERCEPTING DEVICE. L. Teofili, F.Giordano et al. Proceedings of IPAC 2018.

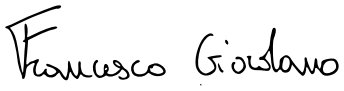
To be submitted in the following days:

- Dependence of LHC beam spectrum and beam induced RF heating with filling scheme. P.Arpaia, L. De Vito, F. Giordano and B. Salvant. Submitted at NIM scientific journal (ELSEVIER)

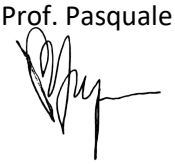
6. Conferences

a. Presentations made
   Poster presentation at the: PhD school Italo Gorini.
   Place: CERN, Geneve, Switzerlan
   Dates: 10-14/09/2018
   Number of posters: 1

Francesco Giordano



Prof. Pasquale Arpaia



[1] G. Apollinari, O. Brüning, T. Nakamoto, L. Rossi, High luminosity large hadron collider hl-lhc, Tech. rep., CERN (2017).
[2] W. Herr, B. Muratori, Concept of luminosity, Tech. rep., CERN (2006).
[3] C. Zannini, G. Rumolo, G. Iadarola, Power loss calculation in separated and common beam chambers of the lhc, Tech. rep., CERN (2014).
[4] A. Mostacci, Beam-wall interaction in the lhc liner, Ph.D. thesis, Rome U. (2001).
[5] G. Rumolo, A. Ghalam, T. Katsouleas, C. Huang, V. Decyk, C. Ren,

W. Mori, F. Zimmermann, F. Ruggiero, Electron cloud effects on beam evolution in a circular accelerator, Physical Review Special Topics-Accelerators and Beams 6 (8) (2003) 08100.
[6] L. Palumbo, V. G. Vaccaro, Wake field: impedances and green's function, Tech. rep., CERN (1987).