



**PhD in Information Technology and Electrical Engineering**

**Università degli Studi di Napoli Federico II**

**PhD Student: Antonio Gilardi**

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**XXXIII Cycle**

**Training and Research Activities Report – Third Year**

**Tutor: Prof. Pasquale Arpaia – co-Tutor: Roberto Corsini**



# Training and Research Activities Report – Third Year

PhD in Information Technology and Electrical Engineering – XXXIII Cycle

Antonio Gilardi

## 1. Information

- Antonio Gilardi, Master degree in Electronic Engineering, 2017, Università degli Studi di Napoli Federico II «*Innovative way to damp the resonances into the CERN accelerators, using HOM couplers*»
- XXXIII Cycle- ITEE – Università di Napoli Federico II
- PhD student enrolled at the PhD student programme at CERN
- Tutor: Prof. Pasquale Arpaia co-Tutor: Roberto Corsini

## 2. Study and training activities

- Seminars (credits in brackets)

“GANT4 Course” presented by Mihaly Novak – Gabriele Cosmo – Vladimir Ivantchenko – John Apostolakis (21/01/2020 - 22/01/2020 - 23/01/2020) (5) CERN

LASER – User training course presented by Jan Troska (6/02/2020) (1) CERN

“PhD School – Italo Gorini” presented by: Luca Callegaro, Anna Amati, Pasquale Filanoti, Nicola Giaquinto, Dario Scarano, Tommaso Tessitore, Stephan Russenschuck, Massimo Rapini, Bruno Andro’, and Antonella Gentile (4/09/2020 - 7/09/2020 - 8/09/2020- 9/09/2020) GMEE - Gruppo di Misure Elettriche ed Elettroniche (1)

## 3. Credits summary

Student: Name Surname		Tutor: Name Surname		Cycle XXXIII																							
<a href="mailto:antonio.gilardi@unina.it">antonio.gilardi@unina.it</a>		<a href="mailto:pasquale.arpaia@unina.it">pasquale.arpaia@unina.it</a>																									
	Credits year 1							Credits year 2							Credits year 3							Total	Check				
	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4			5	6	Summary	
Modules	32	14	14	0	0	4	0	32	8	2	0	2	0	4	0	8	0	0	0	0	0	0	0	0	0	40	30-70
Seminars	11	5	5	0	0	0	1	11	1	0	1	0	0	0	0	1	7	6	0	0	0	1	0	0	7	19	10-30
Research	17	0	0	5	5	3	4	17	51	8	9	8	9	8	9	51	53	7	9	10	10	10	7	53	121	80-140	
	60	19	19	5	5	7	5	60	60	10	10	10	9	12	9	60	60	13	9	10	10	11	7	60	180	180	

Credits adjustments.

## 4. Research activity

- Title: Measurements of wakefields and bunch length with the beam in linear electron accelerators: a case study at the CLEAR facility
- Study: Measurement of electromagnetic interaction between the bunch and the accelerator surroundings
- Research description: I worked as a member of the CLEAR operation team. I actively contributed to the machine operation, acting as a weekly supervisor and following up on my main topics: wake-fields and bunch length studies.  
On top of this, I joined several studies related to irradiation experiments (both medical and electronic hardness assessment) and the R&D on novel beam diagnostics in collaboration with the Beam Instrumentation group.

Regarding my main topic, I developed more robust postprocessing for the wake-field studies and consolidated the system hardware.

Additional beam diagnostics were installed to control better the beam trajectory to allow a more precise study of the wakefield effects.

Some experimental campaigns have been performed to investigate the wake-field effects on single bunches with different lengths and compare the result with analytical formulas. Results show promising conclusions in the understating of the type of wakefields that are affecting the particles.

Regarding the bunch length measurement studies, after a thorough evaluation of state of the art and the measurement technique, it has been assessed that the additional focusing element installed in the CLEAR beamline not only does not corrupt the measurement but allows the direct measurement of two terms (the correlation between the vertical position/divergence and the longitudinal position) not accessible before. Such results were validated using simulations and experimental results.

Other studies have been performed to understand the method's metrological aspects (i.e., the resolution and the uncertainty). The results are pointing out an exciting enhancement. The studies pave the way to further studies to use the CLEAR currently installed layout to improve the measurement feature in other accelerators.

On top of that, the newly installed inductive BPMs are fully commissioned and documented. Moreover, a comparison with the "standard" CLEAR charge measurement system (ICT, Integrated Current Transformer) has been addressed.

This study confirmed and better quantified the correction to be applied to the previous ICT calibration, found wrong following the initial results of my wake-field studies.

As a result of the work performed, several journal articles have been published.

- d. Collaboration: IMPALAB, CLEAR, CLIC, CERN, and INFN working groups

## 5. Products

### a. Publications

- Books, Book Chapters, Journal papers, Conference papers (mark international products):

#### **Journal papers:**

Poppinga, D., Kranzer, R., Farabolini, W., Gilardi, A., Corsini, R., Wyrwoll, V., ... & Poppe, B. (2020). VHEE beam dosimetry at CERN Linear Electron Accelerator for Research under ultra-high dose rate conditions. *Biomedical Physics & Engineering Express*, 7(1), 015012.

Sabato, L., Arpaia, P., Gilardi, A., Mostacci, A., Palumbo, L., & Variola, A. (2020). A Measurement Method Based on RF Deflector for Particle Bunch Longitudinal Parameters in Linear Accelerators. *IEEE Transactions on Instrumentation and Measurement*, 70, 1-9.

Arpaia, P., Corsini, R., Gilardi, A., Mostacci, A., Sabato, L., & Sjobak, K. N. (2020). Enhancing particle bunch-length measurements based on Radio Frequency Deflector by the use of focusing elements. *Nature SR*, 10(1), 1-12.

McManus, M., Romano, F., Lee, N. D., Farabolini, W., Gilardi, A., Royle, G., ... & Subiel, A. (2020). The challenge of ionisation chamber dosimetry in ultra-short pulsed high dose-rate Very High Energy Electron beams. *Scientific Reports*, 10(1), 1-11.

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Curcio, A., Bergamaschi, M., Corsini, R., Farabolini, W., Gamba, D., Garolfi, L., Gilardi, A., ... & Gardelle, J. (2020). Noninvasive bunch length measurements exploiting Cherenkov diffraction radiation. *Physical Review Accelerators and Beams*, 23(2), 022802.

Kokurewicz, K., Brunetti, E., Curcio, A., Gamba, D., Garolfi, G., Gilardi, A., et al. (2021) "An experimental study of the dose distribution of focused very high energy electron (VHEE) beams for radiotherapy". Accepted at Nature Communications Physics.

## Conference papers:

Romano, F., Subiel, A., McManus, M., Lee, N. D., Palmans, H., Thomas, R., Gilardi, A., ... & Ahmed, H. (2020, October). Challenges in dosimetry of particle beams with ultra-high pulse dose rates. In *Journal of Physics: Conference Series* (Vol. 1662, No. 1, p. 012028). IOP Publishing.

Meskova, V., Bouvet, D., Farabolini, W., Gilardi, A., Gkotse, B., Mateu, I., ... & Sidiropoulou, O. Ultra high-level Radiation Monitoring with Thin Metal Nano-Layers (NanoRadMet).

Soderstrom, D., Luza, L. M., Kettunen, H., Javanainen, A., Farabolini, W., Gilardi, A., ... & Dilillo, L. (2020, November). Electron-Induced Upsets and Stuck Bits in SDRAMs in the Jovian Environment. In *IEEE Nuclear and Space Radiation Effects Conference (NSREC)*.

## Main Presentation:

Plenary talk at CLIC Meeting 2020, "CLEAR studies and Wakefield kicks"

Plenary talk at RF Development Meeting 2020, "CLIC main beam accelerating structure wakefield kick measurements in CLEAR"

## Technical Report under review:

Very High Energy Electron RADSAGA Test Campaign  
CLEAR and R2E collaboration

A BEAM PROFILE MONITOR FOR HIGH ENERGY PROTON BEAMS  
USING MICROFABRICATION TECHNIQUES  
CLEAR collaboration

## Awards:

GMEE Borsa Massimo D'Apuzzo 2020

b. List those in preparation:

Title: “Resolution enhancement of a bunch length measurement with radio frequency deflector and a focusing element”

A.Gilardi, P. Arpaia, R.Corsini, A. Mostacci, L. Sabato, K.N.Sjobak

Title: “Uncertainty evaluation of a bunch length measurement with radio frequency deflector and a focusing element”

A.Gilardi, P. Arpaia, R.Corsini, A. Mostacci, L. Sabato, K.N.Sjobak

Title: “An experimental study of the dose distribution of focused very high energy electron (VHEE) beams for radiotherapy”

K. Kokurewicz, E. Brunetti, A. Curcio , D. Gamba , L. Garolfi , A. Gilardi, E. Senes, K. N. Sjobak, W. Farabolini, R. Corsini, and D. A. Jaroszynski

Title: “Evaluating Very High Energy Electron RBE from nanodosimetric pBR322 plasmid DNA damage”

K. L. Small, N. T. Henthorn, D. Angal-Kalinin, A. L. Chadwick, R. C. Morris, E. Santina, A. Aitkenhead, K. J. Kirkby, R. J. Smith, M. Surman, J. Jones, W. Farabolini, R. Corsini, D. Gamba, A. Gilardi, M. J. Merchant, R. M. Jones

Title: “Beam measurements of the CLIC accelerating structure wake-fields in CLEAR”

P. Arpaia, R. Corsini, W. Farabolini, A. Gilardi, K. Sjobaek

## 6. Conferences

- a. Conference name: ATTRACT  
Place: Online conference  
Dates: September 22-23, 2020  
Number of papers: 1
- b. Conference name: IEEE NSREC 2020  
Place: Online conference  
Dates: July 20-24, 2020  
Number of papers: 1
- c. Conference name: IPAC20  
Place: Online conference  
Dates: May 10-15, 2020

Antonio Gilardi



Prof. Pasquale Arpaia

