Gaia Franciosini

Curriculum Vitae

Personal Information

Education

2019–Present **PhD in "Accelerator Physics"**.
"Sapienza", University of Rome.
Title of thesis: Development of a Treatment Control System for IORT FLASH beam
Supervisor: Vincenzo Patera

2017–2019 **Master's degree course in Particle and Astroparticle Physics**.
"Sapienza", University of Rome.
110 with honors /110
Title of thesis: "Time of flight measurements at the FOOT experiment: detector characterization and preliminary results"
Supervisors: Professor Riccardo Faccini. Co-supervisor: Professor Alessio Sarti
Curriculum focuses in Experimental Particle Physics and Medical Physics.

2014–2017 **Bachelor degree in Physics**.
"Sapienza", University of Rome.
109/110
Title of thesis: "Comparison between conventional radiotherapy and hadrontherapy"
Supervisor: Professor Riccardo Faccini.

Teaching Activities

Feb-July 2021 **Co-teacher of Course of Radiation Physics**, *held by Professors Vincenzo Patera and Alessio Sarti*, Departement of Scienze di Base e Applicate all'Ingegneria.

Nov 2020-July 2021 **Co-supervisor of a master student**, *Title thesis: "Radioterapia FLASH con elettroni di alta energia: il caso del tumore alla prostata"*, Departement of Scienze di Base e Applicate all'Ingegneria.

Nov 2020-May 2021 **Co-supervisor of a master student**, *Title thesis: "Sviluppo di un tool per il calocolo Monte Carlo di dose nell'ambito della terapia oncologica intraperatoria (IORT)"*, Departement of Scienze di Base e Applicate all'Ingegneria.

Mar-June 2021 **Lectures and workshop assistant**, *Course of Physics I (Classical Mechanics and Thermodynamics)*, held by Professor Angelo Schiavi, Departement of Ingegneria Chimica, "Sapienza", Univeristy of Rome.
Competition notice n. 400/2020

Sept-Dic 2020 **Lectures and workshop assistant**, *Course of C language*, held by Professor Nicoletta Gnan, Departement of Fisica, "Sapienza", Univeristy of Rome.
Competition notice n. 6/2020

Feb-Jul 2020 **Lectures and workshop assistant**, *Course of Physics (Classical Meachanics, Termodynamics and Electromagnetism)*, held by Professor M. Germano and A. Belardini, Department of Ingegneria Informatica, "Sapienza", Univeristy of Rome.
Competition notice n. 18/2019

Feb-Jul 2020 **Lectures and workshop assistant**, *Course of Physics (Classical Meachanics, Termodynamics and Electromagnetism)*, held by Professor M. Ortolani, Department of Ingegneria Gestionale, "Sapienza", Univeristy of Rome.
Competition notice n. 18/2019

Attended Conferences

[a] FOOT experiment (FragmentatiOn Of Target), Poster Presentation, 10th Young Researcher Meeting, 18^{th}-21^{st} June 2019, Rome, Italy.

[b] Margarita: GSI operation and developments, Oral Presentation, VI FOOT General Meeting at CNAO (Centro Nazionale di Adroterapia Oncologica), 5^{th}-7^{th} June 2019, Pisa, Italy.

[c] Monte Carlo Simulation of an electron beam generated by a mobile iort accelerator, Poster Presentation, SIRR 2020, XIX Congresso Nazionale (ONLINE) , 10^{th}-12^{th} November 2020, Rome, Italy.

[d] Prostate cancer FLASH therapy treatments with electrons of high energy: a feasibility study, Oral Presentation, PTCOG 59 Annual Conference of the Particle Therapy Co-operative Group (ONLINE) , 4^{th}-7^{th} June 2021, Rome, Italy.

[e] Measurements of ^{16}O fragmentation cross sections on C target with the FOOT apparatus, Poster Presentation, PTCOG 59 Annual Conference of the Particle Therapy Co-operative Group (ONLINE) , 4^{th}-7^{th} June 2021, Rome, Italy.

[f] Inter-fractional monitoring in Particle Therapy treatments with ^{12}C ions exploiting the detection of charged secondary particles, Oral Presentation, ANPC Applied Nuclear Physics Conference 12^{th}-17^{th} September 2021, Prague, Czech Republic.

Ph.D. School

13^{th} Jan.-14^{th} Feb. 2020 **JUAS, Joint Universities Accelerator School**, Archamps, France.
Taught by leading European particle accelerators specialists, JUAS delivers a regularly updated, academically accredited training program in partnership with CERN and a cluster of 16 European universities. At the end of the school participants have to undergone an exam to verify the acquired competences. I passed it with 15.10/20
https://www.esi-archamps.eu/Thematic-Schools/Discover-JUAS/JUAS-2020

Awards and Scholarships

Nov. 2020 **Best Poster Presentation**, *SIRR 2020*, XIX Congresso Nazionale (ONLINE), 10^{th}-12^{th} November 2020.
Poster Presention: Monte Carlo Simulation of an electron beam generated by a mobile iort accelerator

23 October 2020 **Excellent student of the 2018/2019 academic year at "La Sapienza", Univeristy of Rome**, *VIII edition of the graduate's day, Univeristy of Rome "La Sapienza"*, https://www.uniroma1.it/it/content/giornata-del-laureato-23-ottobre-2020.

Nov. 2018 – Apr. 2019 **INFN competition for undergraduated students for scientific activities at LNF aimed to the master's degree**, Competition notice n. 19871 (2018).
I decided to present my application for admission in the field of nuclear physics with the FOOT (FragmentatiOn Of Target) experiment
INFN-Laboratori Nazionali di Frascati.
Funding: 2000€

Working

2016-2017 **Collaboration scholarship for student**, *of the Physics Departement at "Sapienza" Università di Roma*.

2017-2018 **Collaboration scholarship for student**, *of the SBAI (Scienze di Base e Applicate all'Ingegneria) Departement at "Sapienza" Università di Roma*.

Research Performances

My research focuses on research and development of new detectors and on application of particle physics detection techniques to different research fields, in particular to the medical one. From 2019:
- h index of 3 with 13 publications in refereed international journals (http://www.scopus.com);
- 6 presentations and seminars at international conferences and workshops;

Publications

[1] Pellegrini R. et al, *Novel gamma tracker for rapid radiation direction detection for UAV drone use*. Paper presented at the 2019 IEEE Nuclear Science Symposium and Medical Imaging Conference, NSS/MIC 2019, DOI:10.1109/NSS/MIC42101.2019.9059630 (2019)

[2] M. Fischetti et al, *Inter-fractional monitoring of ^{12}C ions treatments: results from a clinical trial at the CNAO facility*, Scientific Reports, 10(1) DOI:10.1038/s41598-020-77843-z (2020).

[3] M. Toppi et al, *The MONDO Tracker: Characterisation and Study of Secondary Ultrafast Neutrons Production in Carbon Ion Radiotherapy*, Frontiers in Physics, 8 DOI:10.3389/fphy.2020.567990 (2020).

[4] F. Collamati et al, *Stability and efficiency of a CMOS sensor as detector of low energy β and γ particles*, Journal of Instrumentation, 15(11) DOI:10.1088/1748-0221/15/11/P11003 (2020).

[5] G. Traini et al, *Performance of the ToF detectors in the foot experiment*,Nuovo Cimento Della Societa Italiana Di Fisica C, 43(1). DOI:10.1393/ncc/i2020-20016-5 (2020).

[6] E. Fiorina et al, *Detection of interfractional morphological changes in proton therapy: A simulation and in vivo study with the INSIDE in-beam PET* Frontiers in Physics, 8. DOIi:10.3389/fphy.2020.578388 (2021)

[7] G. Battistoni E. et al, *Measuring the Impact of Nuclear Interaction in Particle Therapy and in Radio Protection in Space: the FOOT Experiment*, Frontiers in Physics, 8. DOI:10.3389/fphy.2020.568242 (2021)

[8] M. Toppi et al, *PAPRICA: The pair production imaging Chamber—Proof of principle*. Frontiers in Physics, 9. DOI:10.3389/fphy.2021.568139 (2021)

[9] A.C. Kraan et al, *Charge identification of nuclear fragments with the FOOT time-of-flight system*. Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 1001. DOI:10.1016/j.nima.2021.165206 (2021)

[10] L. Faillace et al., *Compact S-band Linear Accelerator System for FLASH Radiotherapy*. Physical Review Accelerators and Beams (2021). DOI: 10.1103/PhysRevAccelBeams.24.050102

[11] S. Colombi et al., *Enhancing the understanding of fragmentation processes in hadrontherapy and radioprotection in space with the FOOT experiment*. Physica Scripta, 2021, 96(11), 114013 DOI: https://doi.org/10.1088/1402-4896/ac186b

[12] M. Toppi et al., *Monitoring Carbon Ion Beams Transverse Position Detecting Charged Secondary Fragments: Results From Patient Treatment Performed at CNAO*. Frontiers in Oncology, 2021, 11, 601784 DOI: 10.3389/fonc.2021.601784

[13] G. Galati et al., *Charge identification of fragments with the emulsion spectrometer of the FOOT experiment*. Open Physics, 19(1), 383-394. DOI:10.1515/phys-2021-0032.

Research Activity

My research activity is mainly focused on the study of radiation interactions and in particular to the developments of tools for the medical application field.

During my Master's degree I had the opportunity to work with Professor R. Pani in the nuclear imaging context for an extra-curriculum project. The precise detection of radioactivity, its secure containment and the efficient disposal of all radioactive waste is an ever-increasing concern for the nuclear industry, especially when considering decommissioning or the need for major works at nuclear power plants. In this framework, I developed a compact and handy gamma tracker prototype, dedicated to the direction of radioactive sources. It consists of thin scintillation detectors with cylindrical symmetry coupled with a position sensitive matrix of SiPM. I personally take care of the characterisation with a spectrometer of the prototype detecting elements and irradiating the crystals with collimated ^{133}Ba and ^{57}Co source. Finally I explored the properties of the whole detecting system [1].

For my Master degree thesis I joined the Applied Radiation Physics Group (ARPG) which involves members of INFN, University of Rome "La Sapienza" (Physics and SBAI Departements), and CREF. In particular, my activity has been focused on the FOOT (FragmentatiOn Of Target) experiment [2][3][4]. FOOT is an international collaboration experiment dedicated to significantly improve the precision of the proton Relative Biological Effectiveness (RBE) measurements for particle therapy and space radioprotection applications. The FOOT experiment has been

conceived in order to perform a set of measurements of nuclear cross sections which will be used to develop a new generation of biologically oriented Treatment Planning Systems (TPS) for proton and heavy ion therapy. I gave my main contribution on the analysis of the data taken of 2018 with ^{12}C at Centro Nazionale di Adroterapia Oncologica - CNAO - (Pavia, Italy) and of 2019 with ^{16}O at GSI (Darmstad, Germany) facilities. In particular, I work on the Time Of Flight (TOF) detectors characterisation and development implementing the algorithms needed to optimize the performance of the TOF start detector. The aforementioned algorithms are now implemented into the software developed for the FOOT experiment as standard reconstruction code of the experiment. I present my work at the [a] and [b] international conference.

During my Ph.D I decided to continue my research activity in the ARPGroup focusing my contribution to the development of tools for quality control of therapeutic electron beams. The work has been developed through the optimisation of a fast Monte Carlo code, called FRED (Fast paRticle thErapy Dose evaluator) [5][6], that has been developed as a fast optimizer of TPSs in particle therapy. This software has been written to run on GPU (Graphics Processing Unit), so to reduce the simulation time by a factor of 1000 compared to the standard MC tool. The code is already used as research tool for proton beams, and soon also for carbon ions, at several clinical and research centers in Europe (JPAN center at Krakow, APSS proton therapy at Trento, MAASTRO hospital at Maastricht, CNAO center at Pavia). During my first Ph.D. year I have implemented the algorithms needed to account for what concerns the electron, photons and positron interactions in matter. I cross-checked and benchmarked the FRED results against FLUKA simulations step-by-step, obtaining a very promising agreement. The FRED electromagnetic code is planned to be published as soon as I will finish testing the execution time of the FRED code on GPU.

My Ph.D thesis is now focused on the development of the electromagnetic FRED code in order to extend the use of this MC-on-GPU based software to the Intra Operative RadioTherapy (IORT) technique [7]. The IORT is an irradiation technique that is coupled with surgery treatment of tumor, where an irradiation of the patient surgical breach is made, using electron beams of 7-12 MeV. Currently the two main IORT limitations are the unavailability of a TPS and of a report of the dose delivered. Such limitations are both due to the very limited amount of time available (order of 1 minute) during the surgery to obtain both the imaging of the surgical field and the TPS computation. Since the TPS must be calculate during the surgery, where the patient is highly exposed, it is essential to minimize the simulation time. Due to the speed of the racking algorithms implemented in FRED and to the excellent results achieved in Particle Therapy, I am testing the FRED code with IORT treatment plans collaborating with the Sordina IORT Technologies SpA (SIT) company.

In the context of IORT, I performed also a validation work on the NOVAC 11 mobile accelerator machine for the SIT company. I presented the results obtained at the international conference [c] and I won the award for the best poster presentation of the conference. The same results will be soon published in an article with me as first author [8].

Parallel to the IORT application I am working in the FLASH Therapy [9] context collaborating with the Department of Radiotherapy, Policlinico Umberto I, "Sapienza" University of Rome. Currently I am testing a new approach to cure deep-seated tumors, as prostate cancer, exploiting the FLASH effect, using Very High Energy Electron (VHEE) beams with energies above 50 MeV. The first results demonstrate that FLASH therapy with VHEE beams of 70-130 MeV could represent a valid alternative to standard RT allowing a better sparing of the healthy tissues surrounding the tumour, in the framework of an affordable technological development [10].

In the same context I have also collaborated with the Institute Curie to validate the Electron-Flash mobile linear accelerator dedicated to FLASH treatment and provided by the SIT company [11].

Beside my interest in charged particles detection, I also participated in the development of an innovative neutron tracker for PT applications, MONDO (MOnitor for Neutron Dose in hadrOntherapy). This detector expected performances and the preliminary results obtained so far have been published in [12]. During my Ph.D I also had the chance to cooperate with the ARPGroup at the design and characterisation of an innovative probe for radio-guided surgery, for which an international patent is now pending [13]. A non negligible effort in my PhD activity is focused also on the development of a new detector, the Dose Profiler, a tracker detector capable of monitoring online Particle Therapy treatments in combination with a PET detector to be operated within the INSIDE (Innovative Solution for monitoring inHadrontherapy) project (work presented at [f] international conference)[14][15].

In 2020, my group has been asked to lead the development, construction, test and integration of a beam monitor (BM) for the CNAO experimental room. CNAO requested a detector capable of being directly interfaced with the

Dose Delivery System and the research team's control room. In addition, it should provide the primary ^{12}C ions counting and beam position whenever the beam intensity falls down below 1 MHz, that is the current limit of operation of CNAO standard beam monitors. The goal is to develop a monitor to measure rates up to 10 MHz covering an active area of $\sim$ 13 x 13 cm^2 able to provide feedback about the beam position with an experimental resolution on both views (x,y) of $\sim$ 1 mm. I already participated in the design of a monitor prototype using scintillating fibres with a custom SiPM readout that is matching the CNAO requirements. The full detector construction is now ongoing and its installation is expected in late 2021.