

GAIA FRANCIOSINI

Department of Physics, Sapienza University of Rome, Italy
INFN Sezione di Roma, Italy

EDUCATION

- PhD in Accelerator physics** **2019 - Present**
Sapienza, University of Rome.
Thesis title: *Development of a Treatment Control System for IORT FLASH beam*
Supervisor: Vincenzo Patera
- Master's degree course in Particle and Astroparticle Physics** **2017-2019**
Sapienza, University of Rome
110 with honors/110
Thesis title: *Time of flight measurements at the FOOT experiment: detector characterization and preliminary results*
Supervisors: Riccardo Faccini
Co-supervisor: Alessio Sarti
- Bachelor's degree in Physics** **2014-2017**
Sapienza, University of Rome
109/110
Thesis title: *Comparison between conventional radiotherapy and hadrontherapy*
Supervisor: Riccardo Faccini

TEACHING ACTIVITY

- Tutor** **Mar 2021-Present**
Course of Physics I (Classical Mechanics and Thermodynamics), 9 CFU, held by professor Angelo Schiavi [40h]
Department of Chemical Engineering, Sapienza University of Rome
Competition notice n. 439/2021
- Teaching Assistant** **Nov 2021-Jen 2022**
Course of Physics II (Electromagnetism and Optics), 9 CFU, held by professor Vincenzo Patera [20h]
Department of Scienze di Base e Applicate per l'Ingegneria (SBAI), Sapienza University of Rome
- Teaching Assistant** **Feb-July 2021**
Course of Radiation Physics, 9 CFU, held by professors Vincenzo Patera and Alessio Sarti [20h]
Department of Scienze di Base e Applicate per l'Ingegneria (SBAI), Sapienza University of Rome
- Tutor** **Mar-June 2021**
Course of Physics I (Classical Mechanics and Thermodynamics), 9 CFU, held by professor Angelo Schiavi [40h]
Department of Chemical Engineering, Sapienza University of Rome
Competition notice n. 400/2020
- Tutor** **Sept-Dic 2020**
Course of C/C++/python language, 6 CFU, held by professor Nicoletta Gnan [40h]
Department of Ingegneria informatica, Sapienza University of Rome
Competition notice n. 6/2020
- Tutor** **Feb-July 2020**
Course of Physics (Classical Mechanics, Thermodynamics and Electromagnetism), 12 CFU, held by professor Massimo Germano and Alessandro Belardini [30h]
Department of Ingegneria Informatica, Automatica e Gestionale, Sapienza University of Rome
Competition notice n. 18/2019
- Tutor** **Feb-July 2020**
Course of Physics (Classical Mechanics, Thermodynamics and Electromagnetism), 12 CFU, held by professor Michele Ortolani [30h]
Department of Ingegneria Informatica, Automatica e Gestionale, Sapienza University of Rome
Competition notice n. 18/2019

Co-supervisor of a master student

Sept 2021-Mar 2022

Title thesis: *Un innovativo sistema di pianificazione del trattamento IORT: il caso del tumore al seno.*

Supervisor: Prof. Alessio Sarti, student: Arianna Cerqua.

Department of Scienze di Base e Applicate per l'Ingegneria (SBAI), Sapienza University of Rome

Co-supervisor of a master student

Nov 2020-July 2021

Title thesis: *Radioterapia FLASH con elettroni di alta energia: il caso del tumore alla prostata.*

Supervisor: Prof. Alessio Sarti, student: Damiana Rubeca

Department of Scienze di Base e Applicate per l'Ingegneria (SBAI), Sapienza University of Rome

Co-supervisor of a master student

Nov 2020-May 2021

Title thesis: *Sviluppo di un tool per il calcolo Monte Carlo di dose nell'ambito della terapia IORT.*

Supervisor: Prof. Vincenzo Patera, student: Michela Palma

Department of Scienze di Base e Applicate per l'Ingegneria (SBAI), Sapienza University of Rome

ATTENDED CONFERENCES

Oral Presentation:

1. **A feasibility study of IORT-FLASH using a GPU-based fast Monte Carlo (FRED)**, plenary talk, International Conference on Monte Carlo Techniques for Medical Applications, 11th-13th April 2022, Antwerp, Belgium.
2. **Inter-fractional monitoring in Particle Therapy treatments with ¹²C ions exploiting the detection of charged secondary particles**, parallel talk, ANPC Applied Nuclear Physics Conference 12th-17th September 2021, Prague, Czech Republic.
3. **Prostate cancer FLASH therapy treatments with electrons of high energy: a feasibility study**, parallel talk, PTCOG 59 Annual Conference of the Particle Therapy Co-operative Group (ONLINE) , 4th-7th June 2021, Rome, Italy.
4. **Margarita: GSI operation and developments**, Oral Presentation, VI FOOT General Meeting at CNAO (Centro Nazionale di Adroterapia Oncologica), plenary talk, 5th-7th June 2019, Pisa, Italy.

Poster Presentation:

1. **A feasibility study of deep seated tumor treatments combining FLASH effect and Very High Energy Electron beams**, Poster Presentation, FRPT Flash Radiotherapy & Particle Therapy Conference 1th-3th December 2021, Virtual Conference.
2. **Measurements of ¹⁶O fragmentation cross sections on C target with the FOOT apparatus**, Poster Presentation, PTCOG 59 Annual Conference of the Particle Therapy Co-operative Group (ONLINE) , 4th-7th June 2021, Rome, Italy.
3. **Monte Carlo Simulation of an electron beam generated by a mobile iort accelerator**, Poster Presentation, SIRR 2020, XIX Congresso Nazionale (ONLINE) , 10th-12th November 2020, Rome, Italy.
4. **FOOT experiment (FragmentatiOn Of Target)**, Poster Presentation, 10th Young Researcher Meeting, 18th-21st June 2019, Rome, Italy.

SEMINARS

1. **Development of a Treatment Control System for IORT-FLASH beam**, 9th Jun 2022, XIX Seminar on Software for Nuclear, Subnuclear and Applied Physics, Alghero, Italy
2. **Radiotherapy techniques for cancer treatment**, 13th May 2022, Department of Scienze di Base e Applicate per l'Ingegneria (SBAI), Sapienza, University of Rome.
3. **Nuclear Medicine: PET&SPECT**, 9th May 2022, Department of Scienze di Base e Applicate per l'Ingegneria (SBAI), Sapienza, University of Rome.

XIX Seminar on Software for Nuclear, Subnuclear and Applied Physics 5th-10th Jun 2022

The school hosted a cycle of seminars on particle detectors, a course on machine learning fundamentals and application in physics and a course on GEANT4 and Python programming language.

Alghero, Italy

<https://agenda.infn.it/event/28830/>

INFN, School of Statistics 2022 15th-20th May 2022

The school provided an overview of statistical methods and tools used in particle, astro-particle and nuclear physics.

Paestum, Italy

<https://agenda.infn.it/event/28039/>

JUAS, Joint Universities Accelerator School 13th Jan.- 14th Feb. 2020

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 undergo an exam to verify the acquired competences. I passed it with 15.10/20

Archamps, France

<https://www.esi-archamps.eu/Thematic-Schools/Discover-JUAS/JUAS-2020>

AWARDS AND SCHOLARSHIPS

Best young investigator talk April 2022

International Conference on Monte Carlo Techniques for Medical Application

Orall Presentation: A feasibility study of IORT-Flash using a GPU-based fast Monte Carlo (FRED)

Best Poster Presentation Nov 2020

SIRR 2020, XIX Congresso Nazionale (ONLINE)

Poster Presentation: *Monte Carlo Simulation of an electron beam generated by a mobile iort accelerator*

Excellent student of the 2018/2019 academic year at Sapienza Oct 2020

VIII edition of the graduate's day, Sapienza University of Rome

<https://www.uniroma1.it/it/content/giornata-del-laureato-23-ottobre-2020>

INFN competition for undergraduate students for scientific activities at LNF aimed to the master's degree Nov 2018

I decided to present my application for admission in the field of nuclear physics with the FOOT (FragmentatiOn Of Target) experiment

Istituto Nazionale di Fisica Nucleare, Sezione dei Laboratori Nazionali di Frascati (LNF)

Competition notice n. 19871 (2018)

Funding: 2000 €

GRANTS

Grant for the XIX Seminar on Software for Nuclear, Subnuclear and Applied Physics Jun 2022

5th-10th Jun, Alghero, Italy

INFN, University of Sassari and SNAKE (Sharing Software Knowledge)

FOUNDED PROJECT

As Principal Investigator:**Avvio alla ricerca (Young researcher financing)** 2021-2022

Project: *Development of a Treatment Control System for IORT FLASH beam*

Sapienza, University of Rome

Founding: 1000 €

As a Member:**Call INFN CSN5** 2022-2025

FRIDA-Flash Radiotherapy with high Dose-rate particle beams.

Istituto Nazionale di Fisica Nucleare

Founding: 1M €

POR FESR Lazio 2014-2020 2020

FlashDC-Flash Dose Counting.

Domanda n. PROT. A0375-2020- 36748. Avviso Pubblico “Gruppi di ricerca 2020”

Founding: 149k €

OUTREACH

Tutor for LAB2GO

Dic 2021-May 2022

High school laboratory tutor (Arduino project)

Istituto Nazionale di Fisica Nucleare (INFN) and Physics Department of Sapienza University of Rome.

<https://lab2go.roma1.infn.it/doku.php>

Competition notice: 221/2021 [40h]

WORKING

Collaboration scholarship for student

2016-2017

Department Physics, Sapienza, University of Rome.

Collaboration scholarship for student

2017-2018

Department of Scienze di Base e Applicate per l'Ingegneria (SBAI), Sapienza, University of Rome.

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 4 with 17 publications in refereed international journals (<http://www.scopus.com>);

- 5 oral presentations at international conferences.

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. DOI: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:
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), 11401. DOI:
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.

14. G. Calvi et al., *PAPRICA: The PAir PRoduction Imaging ChAamber*. Nuovo Cimento della Società Italiana di Fisica C, 2021, 44(4-5),147. DOI: 10.1393/ncc/i2021-21147-9.
15. Kraan, A.C. et al., *Localization of anatomical changes in patients during proton therapy with in-beam PET monitoring: A voxel-based morphometry approach exploiting Monte Carlo simulations*. Medical Physics, 2022, 49(1), pp. 23–40. DOI: 10.1002/mp.15336
16. Sarti A. et al., *Deep Seated Tumour Treatments With Electrons of High Energy Delivered at FLASH Rates: The Example of Prostate Cancer* Frontiers in Oncology, 2021, 11, 777852. DOI: 10.3389/fonc.2021.777852.
17. M. De Simoni et al., *A Data-Driven Fragmentation Model for Carbon Therapy GPU-Accelerated Monte-Carlo Dose Recalculation*. Frontiers in Oncology, 2022, 12, 2234-943X. DOI: 10.3389/fonc.2022.780784

RESEARCH ACTIVITY

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

Gamma tracker

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 characterization 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.

FOOT: FragmentatiOn Of Target

For my Master degree thesis I joined the Applied Radiation Physics Group (ARPG) which involves members of INFN, Sapienza, University of Rome (Physics and SBAI Departments), and the Centro Ricerche Enrico Fermi (CREF). In particular, my activity has been focused on the FOOT (FragmentatiOn Of Target) experiment. 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 radio-protection 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 (Darmstadt, Germany) facilities. In particular, I worked on the Time Of Flight (TOF) detectors characterization 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.

FRED: Fast paRticle thErapy Dose evaluator

During my Ph.D I decided to continue my research activity in the ARPGroup focusing my contribution to the development of a fast Monte Carlo, called FRED (Fast paRticle thErapy Dose evaluator). FRED 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).

For the increasing interest in the electron based radiotherapy, especially due to the FLASH effect discovering, during my PhD first two years I have develop the electromagnetic FRED model in order to extend the use of this MC-on-GPU based software as a plan recalculation tool spanning from the energy scale of Intra-Operative Radio Therapy IORT ($\sim 5\text{-}10\text{MeV}$) up to that of Very High Energy Electrons (VHEE) radiotherapy ($\sim 100\text{ MeV}$).

IORT Treatment Planning System

My Ph.D thesis is now focused on the development of a TPS for IORT and IORT-FLASH. The IORT is a technique that, after the surgical tumor removal, delivers a dose of ionizing radiation (4-12 MeV electrons beam) directly to the surgery bed. During IORT treatments the beam is passively collimated by means of a PMMA hollow tube and whenever needed, temporarily beam modifiers are used to protect the healthy tissues surrounding

the target. The use of high intensity pulses of electrons makes IORT the current best candidate for the first implementation of the FLASH effect into clinic. An important IORT limitation is the lack of a TPS capable of coping with the very limited amount of time available after the surgery (1 min) to obtain both the new imaging of the surgical field, which has undergone substantial morphological modification, and the TPS computation. In my last PhD year, exploiting the new 3D real-time echographic imaging acquisition provided by the SIT company (Aprila, Italy), I'm investigating the efficiency achievable in IORT and IORT-FLASH treatment using FRED.

Very High Energy Electrons and Flash effect

Parallel to the IORT application I am working in the FLASH Therapy 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 and pancreatic cancer, exploiting the FLASH effect, using 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. In the same context I have also collaborated with the Institute Curie to validate the Electron-Flash mobile linear accelerator dedicated to FLASH studies and provided by the SIT company.

MONDO: neutron tracker

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).

Radio-guided surgery

During my Ph.D I also had the chance to cooperate with the ARPGroup at the design and characterization of an innovative probe for radio-guided surgery, for which an international patent is now pending.

Dose Profiler

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.