

GAIA FRANCIOSINI

CURRENT AND PREVIOUS POSITIONS

Postdoctoral Researcher FIS/01 **01/05/2023 - Current**
Project title: Development of a VHEE accelerator at Sapienza University for the treatment of deep seated tumors: planning and magnetic delivery of a FLASH compact beam.
Department of Basic and applied sciences for engineering
Sapienza, University of Rome, Italy
Competition notice: AR-A 38/2022 Prot n 915 del 27/04/2023 Rep n. 26 Classi VII/2.

Research Fellowship **01/01/2023-30/04/2023**
Project title: *Development and Application of linear accelerator*
Department of Basic and applied sciences for engineering
Sapienza, University of Rome, Italy
Competition notice: B2-2 36/2022 Prot n. 3105 del 21/12/2022 Rep n.50 Class VII/1.

EDUCATION

PhD in Accelerator physics **2019 - 2022**
Excellent with honors
Project title: *Development of a Treatment Control System for IOeRT FLASH beam*
Thesis Advisor: Vincenzo Patera, Co-Advisor: Angelo Schiavi
Sapienza, University of Rome-Department of Physics

Master's degree course in Particle and Astroparticle Physics **2017-2019**
110/110 *cum laude*
Project title: *Time of flight measurements at the FOOT experiment: detector characterization and preliminary results*
Thesis Advisor: Riccardo Faccini, Co-Advisor: Alessio Sarti
Sapienza, University of Rome-Department of Physics

Bachelor's degree in Physics **2014-2017**
109/110
Project title: *Comparison between conventional radiotherapy and hadrontherapy*
Thesis Advisor : Riccardo Faccini
Sapienza, University of Rome-Department of Physics

FOUNDED PROJECTS AS PRINCIPAL INVESTIGATOR

Avvio alla ricerca (Young researcher financing) **2022-2023**
Project title: Treatment Planning optimization for breast cancer IOeRT-FLASH treatments,
Funding from *Sapienza*, University of Rome, Italy

Avvio alla ricerca (Young researcher financing) **2021-2022**
Project title: Development of a Treatment Control System for IORT FLASH beam,
Funding from *Sapienza*, University of Rome, Italy

FOUNDED PROJECTS AS A MEMBER

"MIRO" (MInibeam RadiOtherapy) - Call CSN5 INFN **2022-Current**
I participate in WP2 with the Reference & in-vivo dosimetry activities and in WP4 with Planning and clinical perspectives. Founding 2023: 100 k€. PI: Francesco Romano (INFN Catania, Italy)

"FRIDA" (Flash Radiotherapy with high Dose-rate particle beAms)-Call CSN5 INFN **2022-Current**
I participate in WP2 in the beam monitor development and in WP4 with MC development. Funding 2022: 225 keuro. PI: Alessio Sarti (*Sapienza* University, SBAI Department)

"FlashDC" (Flash Detector Counter) - MUR **2020-Current**
Domanda n. PROT. A0375-2020- 36748. Avviso Pubblico "Gruppi di ricerca 2020" - POR FESR Lazio 2014-2020. Funding: 149 keuro. PI: Michela Marafini (CREF)

"FOOT Experiment" (FragmentatiOn Of Target)- CSN3 INFN **2016-Present**
PI: Mauro Villa (Alma Mater University of Bologna)

TEACHING EXPERIENCE

Contract Teacher **a.y. 2022-2023**

Course of Physics I (Thermodynamics) for Energetic Engineering 3 CFU [30h]

Sapienza, University of Rome

Competition notice n. 11/2023, Prot 926 27/04/2023

Tutor

a.y. 2019-2023

Since 2019, I have been the tutor for the following courses at *Sapienza*, University of Rome:

- Course of Physics I (Classical Mechanics and Thermodynamics) held by professor A. Schiavi [40h], Chemical Engineering, *Sapienza*, University of Rome, a.y. 2022/2023. Competition notice n. 416/2022;
- Course of Physics II (Electromagnetism and Optics) held by professor V. Patera [40h], Biomedical Engineering, *Sapienza*, University of Rome, a.y. 2022/2023. Competition notice n. 428/2022;
- Course of Physics I (Classical Mechanics and Thermodynamics) held by professor A. Schiavi [40h], Chemical Engineering, *Sapienza*, University of Rome, a.y. 2021/2022. Competition notice n. 439/2021;
- Course of Physics I (Classical Mechanics and Thermodynamics), held by professor A. Schiavi [40h]. Chemical Engineering, *Sapienza*, University of Rome, a.y. 2020/2021. Competition notice n. 401/2020 ;
- Course of computational laboratory (C/C++/python language) held by professor Nicoletta Gnan [40h], Department of Physics, *Sapienza*, University of Rome, a.y. 2020/2021. Competition notice n. 6/2020;
- Course of Physics (Classical Mechanics, Thermodynamics and Electromagnetism), held by professor M. Germano and A. Belardini [30h], Department of Ingegneria Informatica, Automatica e Gestionale, *Sapienza*, University of Rome, a.y. 2019/2020. Competition notice n. 18/2019;
- Course of Physics (Classical Mechanics, Thermodynamics and Electromagnetism), held by professor M. Ortolani [30h], Department of Ingegneria Informatica, Automatica e Gestionale, *Sapienza*, University of Rome, a.y. 2019/2020. Competition notice n. 18/2019.

Co-supervisor of 5 master students

2020-Current

Biomedical Engineering, Department of Basic and Applied Science for Engineering (SBAI), *Sapienza*, University of Rome, Italy

COMMISSION OF TRUST

Member of the PTCOG Early Career Researchers (PTCOG-ECR) Subcommittee **2023-Current**

Established during the 61st PTCOG conference, the PTCOG-ECR subcommittee is a dedicated group representing the interests of emerging researchers and practitioners in particle therapy.

Member of the organisation committee of the Lecito magistralis by Vincent Favaudon **25/10/2022**

From conventional dose-rate to FLASH radiotherapy, Vincent Favaudon, Institute Curie. *Sapienza*, University of Rome, Italy.

AWARDS

Premio Minerva alla Ricerca scientifica (Minerva Award for Scientific Research) **12/2023**

Macroarea A - PhD student category, Rome Sapienza Foundation, iV edition

Sapienza, University of Rome, 6th December, Rome, Italy

Grant for the XIX Seminar on Software for Nuclear, Subnuclear and Applied Physics **06/2022**

5th-10th Jun, Alghero, Italy

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

Young Investigator Award (YIA) granted by the European Radiation Research Society **23/09/2022**

47th Annual Meeting of the European Radiation Research Society (ERRS)

21th-24th Sept 2022, Catania, Italy

Best young investigator talk **13/04/2022**

International Conference on Monte Carlo Techniques for Medical Application

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

Best Poster Presentation **12/10/2020**

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 of the faculty of mathematical, physical and natural sciences at *Sapienza* **23/10/2020**

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

Scientific activities at LNF

27/07/2018

INFN Competition for undergraduate master students

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

Competition notice n. 19871 (2018)

Funding: 2000 €

TRAINING SCHOOL

GSI-ESA-FAIR Space Radiation School 2022

04/09/2022-19/09/2022

The school trains students in basic heavy ion biophysics for both terrestrial and space applications. It provides lectures from experts and practical training

Darmstadt, Germany

XIX Seminar on Software for Nuclear, Subnuclear and Applied Physics

05/06/2022-10/06/2022

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

INFN, School of Statistics 2022

15/05/2022-20/05/2022

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

Paestum, Italy

JUAS, Joint Universities Accelerator School

13/01/2020-14/02/2020

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

RESEARCH PERFORMANCES, EXPLOITATION AND DISSEMINATION

My research activity is focused on the development of new detectors and software tools mainly related to **particle physics applied to the medical field**. The scientific outcome of my research is reported in several publications on refereed journals and presentation at conferences and seminars. From 2019:

- h index of 8 with 34 publications in refereed international journals for a total of more than 173 citations (database: <http://www.scopus.com>);
- 2 publications in refereed international journals as first author, last or corresponding author;
- 9 oral presentations at international conferences and workshops;

During my research activities, I have exploited several international collaborations among which the main ones are:

- Collaboration with **Centro Nazionale di Adroterapia Oncologica - CNAO** (Pavia, Italy) for the development of a beam monitor for low intensity heavy ion beams.
- Collaboration with the **Curie Institute** (Orsay, France) for the dosimetric characterization of FLASH electron beams.
- Collaboration with the University of Texas **M. D. Anderson Cancer Center** for the potential study of VHEE focused beam for the treatment of deep seated tumours;
- Collaboration with the University of Washington & Fred **Hutchinson Cancer Center** (Seattle, USA) for the potential study of VHEE both in conventional and FLASH irradiation modes for the treatment of deep seated tumours;
- Collaboration with the **GSI Helmholtz Centre for Heavy Ion Research** (Darmstadt, Germany) for the development of a Treatment Planning System AI based for Carbon ions treatments;

The technology transfer is of large importance in applied physics. I devote a huge effort to make TT of our research possible through the exploitation of different possible paths:

- From 2023 - Founder Member of **DARTS srl Startup** - Diagnostics and Applications for Technology and Simulations. DARTS operates by commercially valorising the research activity of its founding members relating to the study, understanding and modelling of the interaction between radiation (in particular ionising radiation) and matter.

- Collaboration with the **S.I.T. Sordina IORT Technologies** for the development of a Treatment Planning System dedicated to Intra Operative Radio Therapy with electrons (IOeRT) treatments;

Large public communication and dissemination activity:

- **Tutor for LAB2GO** From 12/2021 to 05/2022. 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]

TRACK RECORD

My research activity is mainly focused on the study of radiation interactions, particularly on the development of new detectors and software tools for the medical application field. Since 2019, I have worked on various projects as a member of the Applied Radiation Physics group (ARPG) at *Sapienza* University of Rome.

I started my journey in the landscape of radiotherapy by joining the FOOT (FragmentatiOn Of Target) collaboration for my Master degree thesis [5]. FOOT is an international experiment dedicated to improving the precision of proton Relative Biological Effectiveness (RBE) measurements for Particle Therapy (PT), both with protons and carbon ions, and space radio-protection applications. The FOOT experiment was conceived 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 to the analysis of the data taken in 2018 with ^{12}C at Centro Nazionale di Adroterapia Oncologica - CNAO - (Pavia, Italy) and in 2019 with ^{16}O at GSI (Darmstadt, Germany) facilities, working on Time Of Flight (TOF) detectors' characterization and development.

My experience in the different projectiles used for External Beam Radio Therapy (EBRT) greatly increased when I started my Ph.D. studies working also in the FLASH radiotherapy field. My contribution was initially related to the planning of Intra-Operative electron Radio Therapy (IOeRT) treatments using electrons of low energy, but then I also started contributing to the development of a new EBRT technique involving Very High Energies Electrons (VHEE), i.e. above 50 MeV[7]. The study of such scenarios (both IOeRT and VHEE plans in conventional and FLASH irradiation modalities) started facing a difficult task: the development of a fast Monte Carlo software tool capable of exploring different irradiation configurations, energies, intensities to allow a real MC-based optimization of the treatment. My efforts were focused on the FRED (Fast paRticle thErapy Dose evaluator) electromagnetic model development [1,3]. FRED is a fast, GPU-accelerated dose engine based on Monte Carlo (MC) simulation, designed to enable rapid optimization of TPS in PT while maintaining the dose release accuracy characteristic of full MC tools [10]. Leveraging the parallel programming capabilities of GPUs, FRED significantly reduces simulation time by a factor of 1000 compared to standard MC tools. Throughout my Ph.D., I integrated electromagnetic interaction models for electrons, positrons, and gamma into the FRED software, balancing calculation speed and the accuracy of implemented physical models. With this tool, and with the help of the S.I.T. Sordina IORT Technologies S.p.A. company (Aprilia, Italy), and the input of various hospitals across Europe (e.g. Iridium Kankernetwerk in Antwerp, Belgium and the IEO - Istituto Europeo di Oncologia in Milan, Italy), I was able to successfully implement the first-ever complete online TPS for Intra-Operative electron RadioTherapy (IOeRT). Such a tool, long-awaited, has the potential to significantly improve the IOeRT technique, overcoming its current main limitations (e.g. the relatively high probability of tumor local recurrence caused by the lack of a real planning tool). The tool will also pave the way for the most probable first clinical translation of the FLASH effect, as IOeRT FLASH treatments are already possible, and the FLASH-related evidence has been so far obtained with such accelerators (FLASH, low energy, e⁻).

Parallel to my PhD project and during my Post-Doc activity I have worked on VHEE applications. I joined a Sapienza and INFN interdisciplinary team, SAFEST (SApienza Flash Electron Source for radio-Therapy), which will build inside the university a FLASH VHEE facility [6], and FRIDA (Flash Radiotherapy with high Dose-rate particle beAms, Call INFN CSN5) which aims to study the FLASH effect potential with both protons and electrons, to investigate the efficiency achievable in VHEE treatments to treat deep-seated tumors. I shared the expertise on MC simulation for clinical applications gained from the FRED experience for the development of a TPS dedicated to VHEE beam delivery in conventional and FLASH regimes. I investigated the VHEE therapy potential in the cases of prostate, head and neck, and pancreatic tumors [4,8]. A non-negligible effort of my research activity inside the FRIDA collaboration is today focused on the development of a beam monitor dedicated to next-generation beams at FLASH intensities based on air fluorescence. Besides that, my interests covers FLASH radiotherapy in other possible configurations such as the GRID therapy (mini beams) [2], as a member of MIRO, and Focused VHEE therapy, in collaboration with the M. D. Anderson Cancer Center, where magnetic fields are used to guide

and focus the trajectory of VHEE beams, providing an additional layer of precision in targeting tumors and enhancing the sparing the superficial tissue in the entrance channel.

My research activity, as a PhD and Post-Doc, has not only been focused on software development but also hardware. During my PhD activity, I participated in the development of two innovative particle trackers for range monitoring purposes during PT treatments: the MONDO (MONitor for Neutron Dose in hadrOntherapy) neutron tracker and the Dose Profiler, a charged particle tracker detector capable of monitoring online PT treatments in combination with a PET device to be operated within the INSIDE (Innovative Solution for monitoring inHadrontherapy) project [9]. Collaborating with CNAO I gave my contributed to the development of a beam monitor for low-intensity protons and heavy ion beams.

WORKSHOPS AND CONFERENCES

Oral Presentation:

- IOeRT conventional and FLASH treatment planning system implementation exploiting fast GPU Monte Carlo: the case of breast cancers**
Parallel talk
Workshop Società Italiana per la Ricerca sulle Radiazioni (SIRR) 2023
29th-30th November 2023, Rome, Italy.
- External beam radiotherapy with electrons of low (IOeRT) and high (VHEE) energies: status and prospects for conventional and FLASH irradiations**
Parallel talk
109^o Congress of Italian Physics Society (SIF) 2023, 11th-15th September 2023, Fisciano, Italy.
- Status of the FOOT experiment and first measurements of ¹⁶O fragmentation cross sections on C target**
Parallel talk
The 6th Technology and Instrumentation in Particle Physics (TIPP 2023) conference
4th-8th September 2023, Cape Town, South Africa.
- Development of a IORT Treatment Planning System using a GPU-based fast Monte Carlo,**
Plenary talk
47th Annual Meeting of the European Radiation Research Society (ERRS 2022)
21th-24th September 2022, Catania, Italy.
- A feasibility study of IORT Treatment Planning system using a GPU based fast Monte Carlo**
Parallel talk
4th European Congress of Medical Physics
17th-20th August 2022, Dublin, Ireland.
- 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.
- 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.
- 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.

Poster Presentation:

- Planning IOeRT FLASH treatments with a GPU-based Monte Carlo: The case of breast cancer,** Poster Presentation, PTCOG 61 Annual Conference of the Particle Therapy Co-operative Group, 10th-16th June 2023, Madrid, Spain.
- 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. **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.
4. **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.

SEMINARS

1. **Development of a Treatment Control System for IORT-FLASH beam**
XIX Seminar on Software for Nuclear, Subnuclear and Applied Physics, 9th Jun 2022, Alghero, Italy

SCIENTIFIC PRODUCTS: SELECTION OF 15 PUBLICATIONS HIGHLIGHTING MY PERSONAL CONTRIBUTIONS

1. G. Franciosini et al., *Preliminary study on the correlation between accelerated current and dose in water for an electron-based LINAC*
Frontiers in Physics, 2024, 12 , 2296-424X
DOI: 10.3389/fphy.2024.1249393
0 citations counted in Scopus as of March 19, 2024
IF: 3.1 (2024)
2. G. Franciosini et al., *GPU-accelerated Monte Carlo simulation of electron and photon interactions for radiotherapy applications*
Physics in Medicine & Biology, 2023, 68(4), 044001
DOI 10.1088/1361-6560/aca1f2
3 citations counted in Scopus as of March 19, 2024
IF: 3.902 (2023)
3. J.H. Pensavalle et al., *Realization and dosimetric characterization of a mini-beam/flash electron beam*
Frontiers in Physics, 2023, 11, 2296424X
DOI: 10.3389/fphy.2023.1269495
0 citations counted in Scopus as of March 19, 2024
IF: 3.17 (2023)
4. A. Muscato et al., *Treatment planning of intracranial lesions with VHEE: comparing conventional and FLASH irradiation potential with state-of-the-art photon and proton radiotherapy*
Frontiers in Physics, 2023, 11, 1185598
DOI: 10.3389/fphy.2023.1185598
3 citations counted in Scopus as of March 19, 2024
IF: 3.17 (2023)
5. L. Giuliano, G. Franciosini et al., *Characterization of Ultra-High-Dose Rate Electron Beams with Electron-Flash Linac*
Applied Sciences (Switzerland), 2023, 13(1), 631
DOI: 10.3390/app13010631
8 citations counted in Scopus as of March 19, 2024
IF: 2.838 (2023)
6. L. Faillace et al., *Perspectives in linear accelerator for FLASH VHEE: Study of a compact C-band system*
Physica Medica, 2022, 104, pp. 149–159
DOI: 10.1016/j.ejmp.2022.10.018
6 citations counted in Scopus as of March 19, 2024
IF: 2.685 (2022)
7. M. Toppi et al., *Elemental fragmentation cross sections for a 16O beam of 400 MeV/u kinetic energy interacting with a graphite target using the FOOT ΔE-TOF detectors*
Frontiers in Physics, 2022, 10, 979229
DOI: 10.3389/fphy.2022.979229
1 citations counted in Scopus as of March 19, 2024
IF: 3.560 (2022)

8. A. Trigilio et al., *The FlashDC project: Development of a beam monitor for FLASH radiotherapy* Nuclear Instruments and Methods in Physics Research, Section A, 2022, 1041, 167334.
DOI: 10.1016/j.nima.2022.167334
2 citations counted in Scopus as of March 19, 2024
IF: 1.455 (2022)
9. A. Rahman et al., *FLASH radiotherapy treatment planning and models for electron beams* Radiotherapy and Oncology, 2022, 12, 929949,.
DOI: 10.1016/j.radonc.2022.08.009
10 citations counted in Scopus as of March 19, 2024
IF: 6.280 (2022)
10. 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
5 citations counted in Scopus as of March 19, 2024
IF: 6.244 (2022)
11. 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.
14 citations counted in Scopus as of March 19, 2024
IF: 6.244 (2022)
12. 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
17 citations counted in Scopus as of March 19, 2024
IF: 2.24 (2021)
13. 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)
25 citations counted in Scopus as of March 19, 2024
IF: 3.56 (2021)
14. 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).
13 citations counted in Scopus as of March 19, 2024
IF: 4.13 (2020)
15. 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).
0 citations counted in Scopus as of March 19, 2024
IF: 3.560 (2020)