MATTEO BARBETTI

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Research Activities

I am a third-year Ph.D. student in Smart Computing at the University of Florence. My research activity is mainly dedicated to the development of LAMARR [1], the new LHCb ultra-fast simulation framework. Lamarr consists of a pipeline of modular parameterizations designed to replace both the physics simulation and the reconstruction steps. Most of the parameterizations rely on Machine Learning algorithms [2], such as generative models that have proven to be able to well reproduce the detailed simulation [3].

As an active developer for Lamarr, I am responsible for the development of parameterizations for the LHCb PID system. Obtaining high-quality distributions for such class of models is a non-trivial task and requires intensive hyperparameter optimization studies. Thus, Bayesian strategies have been explored to run optimization campaigns in parallel, and exploit opportunistic GPU resources. In this context, I have developed Hopaas [4], a cloud service that allows to orchestrate optimization studies across multiple computing instances via simple HTTP requests. Hopaas allows to obtain performing parameterizations that can easily replace specific modules without recompiling the whole LAMARR pipeline using scikinC [5], a tool able to transpile Machine Learning models to C files.

Besides my involvement within the LAMARR development, I have also contributed to apply Machine Learning techniques to Medical Physics. In particular, I have developed a Machine Learning model powered by Radiomics to infer the histological type of mediastinal bulky lymphoma masses [6].

My research activity fits perfectly with what carried out by the LHCb Florence Group that plays a key role with detector simulation and cosmic ray physics. State-of-the-art techniques are applied successfully both for fast simulation and physics analysis where, in particular, the LHCb Florence Group is author of a novel approach based on Machine Learning to model the PID response to antiprotons by LHCb in fixed-target mode [7].

EDUCATION

University of Florence

Firenze, Italy

PH.D. IN SMART COMPUTING

Nov 2020 - present

Ph.D. scholarship funded by INFN to carry out Machine Learning research for Physics applications Main activities carried out:

- Software development for Lamarr, the LHCb ultra-fast simulation framework
- Cloud applications development to coordinate Bayesian optimization studies
- Contribution to the LHCb distributed computing operations
- Application of Machine Learning techniques to Medical Physics

Advisory Board: Lucio Anderlini, Denis Derkach, Michael Williams

University of Florence

Firenze, Italy

⋒.Sc. in Particle Physics

Sep 2017 - Jun 2020

Thesis Title: "Techniques for parametric simulation with deep neural networks and implementation for the LHCb experiment at CERN and its future upgrades" (CERN-THESIS-2020-416)

Thesis Advisors: Lucio Anderlini, Piergiulio Lenzi

Thesis Award: "Giulia Vita Finzi" INFN award for the best thesis on computing and networks

Graduation Score: 110/110 cum laude

https://mbarbetti.github.io Last updated: December, 2022

University of Florence

Firenze, Italy

B.Sc. in Physics and Astrophysics

Sep 2013 - Sep 2017

Thesis Title: "Study of the charmonium resonances in $B^+ \to p\bar{p}K^+$ and $B^+ \to p\bar{p}\gamma K^+$ decays with the LHCb experiment at CERN" (CERN-THESIS-2017-496)

Thesis Advisors: Lucio Anderlini, Giuseppe Latino

Graduation Score: 110/110

EXPERIENCE

University of Florence

Firenze, Italy

➡ Tutor Senior (Laboratory Tutor and Teaching Assistant)

Jan 2021 – present

Scholarship funded by a local grant from the University of Florence for a total of 150 hours/year Main activities carried out:

- Introductory lessons to Python for third-year students of the B.Sc. in Physics
- Physics exercises discussed in class for the B.Sc. in Mathematics students
- Support to Physics Laboratory activities for the B.Sc. in Mathematics

INFN Firenze, Italy

昔 Trainee

Feb 2020 – Apr 2020

Main activities carried out:

- Software development of deep generative models for the LHCb fast simulation
- Networking with the LHCb Florence Group

CERN Geneva, Switzerland

♣ Research Intern

Sep 2019 - Dec 2019

Internship funded by a national grant from INFN to pass three months at CERN Main activities carried out:

- Investigating Machine Learning techniques to parameterize the LHCb detector
- Software development for the LHCb fast simulation
- Networking with the LHCb Simulation Project

University of Florence

Firenze, Italy

TUTOR (LABORATORY TUTOR AND TEACHING ASSISTANT)

Oct 2018 - Dec 2020

Scholarship funded by a local grant from the University of Florence for a total of 200 hours/year Main activities carried out:

- Support to Physics Laboratory activities for the B.Sc. in Biological Sciences and Physics
- Physics exercises discussed in class for the B.Sc. in Biological Sciences students
- Introductory lessons to Python for third-year students of the B.Sc. in Physics

University of Florence

Firenze, Italy

昔 Tutor Junior (Student Assistant)

 $Jun\ 2018-Oct\ 2018$

Scholarship funded by a local grant from the University of Florence for a total of 200 hours Main activities carried out:

- Communicator at "ScienzEstate", a dissemination event to promote scientific research at Florence
- Orientation service for students of the Science Faculty of the University of Florence
- Welcome service for students from the Erasmus Plus Program

CERN Geneva, Switzerland

= Trainee

Jul 2017

Traineeship of two weeks at CERN funded by a local grant from the University of Florence Main activities carried out:

- Finalization of the bachelor thesis at CERN
- Networking with the LHCb Charmonium Working Group

University of Florence

Firenze, Italy

2022

♣ Assistant Librarian

Oct 2016 - Dec 2016

Scholarship funded by a local grant from the University of Florence for a total of 150 hours Main activities carried out:

- Support to students at the Science Library of the University of Florence
- Cataloguing of Geology historical theses

TEACHING & TUTORING

INFN Educational Events, INFN

- Third ML-INFN Hackathon: Advanced Level "Bayesian hyperparameter optimization" 2022
- Third ML-INFN Hackathon: Advanced Level "Introduction to generative models"

B.Sc. in Physics and Astrophysics, University of Florence

- B015862: Physics Laboratory III Laboratory Tutor and Teaching Assistant 2020 2023
- B015860: Physics Laboratory I Laboratory Tutor 2020 2021

B.Sc. in Mathematics, University of Florence

- B016237: Physics II with Laboratory Laboratory Tutor 2021 2023
- B016236: Physics I with Laboratory Laboratory Tutor and Teaching Assistant 2022 2023

B.Sc. in Biological Sciences, University of Florence

- B019238: Physics Laboratory for Biology Laboratory Tutor and Teaching Assistant 2018 2020
- B019231: Physics Teaching Assistant 2018 2019

LEADERSHIP & COMMUNITY SERVICES

Italian National Institute for Nuclear Physics 🏶

• Tutor at ML-INFN educational events Jan 2020 – present

LHCb Collaboration

- Data Quality, Computing and Simulation shifter Mar 2021 present
- Lamarr active developer for the Simulation Project Nov 2020 present

Italian Association of Physics Students

- Deputy-President
 National Secretary
 President of the Florence Local Committee
 Editorial Board Member of "Sistemi di Riferimento"
 Oct 2020 Sep 2021
 Nov 2019 May 2019
 May 2018 Sep 2021
- Deputy-President of the Florence Local Committee Dec 2017 Nov 2018

Last updated: December, 2022

International Schools

4th International School on Open Science Cloud 🏶

Perugia, Italy

INFN, University of Perugia & University of Bologna

Nov 2022

Theme: Computing Models for Scientific Experiments

with diploma

8th Thematic CERN School of Computing

online

CERN School of Computing

Jun 2021

Theme: Scientific Software for Heterogeneous Architectures

with diploma

2nd Summer School in Physical Sensing and Processing

online

University of Bologna

Jul 2020

Theme: Sensing devices, DAQ systems, and data processing strategies

Poster: "Hyperparameter Optimization as a Service on INFN Cloud"

participation only

Workshops & Conferences

ACAT 2022 🏶

Bari, Italy

University of Bari, Polytechnic University of Bari & INFN Bari

Oct 2022

Poster: "Lamarr: LHCb ultra-fast simulation based on machine learning models"

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108° Congresso Nazionale della SIF 🏶

Milan, Italy

Italian Physical Society (SIF)

Oral: "ML in the histological differentiation of mediastinal bulky lymphoma"

Sep 2022

4th European Congress of Medical Physics

Dublin, Ireland

European Federation of Organisations for Medical Physics

Aug 2022

Oral: "ML in the histological differentiation of mediastinal bulky lymphoma"

Learning To Discover 🏶 Institut Pascal Paris-Saclay

Orsay, France Apr 2022

Oral: "Simulating the LHCb experiment with Generative Models"

LPCC Fast Detector Simulation Workshop

online

LHC Physics Centre at CERN

Nov 2021

Oral: "OptunAPI: API to distribute hyperparameters optimization through HTTP requests"

107° Congresso Nazionale della SIF 🏶

online Sep 2021

Italian Physical Society (SIF) Oral: "Simulating the LHCb detector with GANs"

Workshop della Commissione Calcolo e Reti dell'INFN

online

INFN Computing and Network Service

May 2021

Oral: "Simulating the LHCb detector with GANs"

online

1st CloudBank EU Workshop 🏶

CERN IT & IPT Departments

Apr 2021

Oral: "LHCb deployment in AWS" (restricted access)

Organization of Outreach Events

Third ML-INFN Hackathon: Advanced Level Bari, Italy INFN Nov 2022 Organizing committee member for an INFN educational event about Machine Learning Live interview "Fisica del Clima" with Daniele Visioni online AISF & Cornell University Mar 2021 Organization of an interview about Climate Physics Live interview "Women in Science" with Anna Gregorio online Feb 2021 AISF & University of Trieste Organization of an interview on the occasion of Women in Science International Day Live interview "COVID19" with Eugenio Valdano online AISF & INSERM Apr 2020 Organization of an interview about statistical models for COVID-19 pandemic Outreach event "Tra clima e cocktail" Firenze, Italy AISF, Italian Climate Network, CNR & University of Florence May 2019 **(1)** Organization of an event aimed to raise awareness about climate change problem Outreach event "Viaggio al Polo" Firenze, Italy AISF, Caffè-Scienza, INFN & University of Florence May 2019 **(1)** Organization of an event about intelligence according to various scientific domains Outreach event "Luminoscienza" Firenze, Italy

> May 2018 **(1)**

> > **(1)**

online

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Padova, Italy Oct 2018

Firenze, Italy Oct 2017

AISF, LENS, University of Florence, INRIM & Caffè-Scienza

Organization of three scientific evenings on the occasion of International Day of Light

Seminar "The new particles of LHCb" by Lucio Anderlini

Organization of a seminar to discuss latest LHCb discoveries

OUTREACH & DISSEMINATION

Editorial board of "Sistemi di Riferimento"

AISF May 2018 - Sep 2021

"SdR" is a dissemination project to promote Italian Physics Departments activities

Science book "Invenzioni"

Sassi Junior & INFN Jun 2021

Preparation of a paragraph dedicated to Artificial Intelligence

Jury member for "Premio Galileo"

City of Padova & University of Padova

"Premio Galileo" is a literary prize for science dissemination

Blog author online

Apr 2016 - Oct 2017 Fisici Senza Palestra

Writing science dissemination articles for the "Fisici Senza Palestra" blog

SELECTED PAPERS

- [1] L. Anderlini et al., Lamarr: the ultra-fast simulation option for the LHCb experiment, in 41st International Conference on High Energy Physics – PoS(ICHEP2022), 414 233, 2022
- [2] F. Ratnikov et al., A full detector description using neural network driven simulation, in 15th Pisa Meeting on Advanced Detectors, Nucl. Instrum. Meth. A 1046 (2023) 167591
- [3] L. Anderlini et al., Towards Reliable Neural Generative Modeling of Detectors, in 20th International Workshop on Advanced Computing and Analysis Techniques in Physics Research, arXiv:2204.09947
- [4] M. Barbetti and L. Anderlini, Hyperparameter Optimization as a Service on INFN Cloud, in 21st International Workshop on Advanced Computing and Analysis Techniques in Physics Research, in preparation for J. Phys. Conf.
- [5] L. Anderlini and M. Barbetti, scikinC: a tool for deploying machine learning as binaries, in Computational Tools for High Energy Physics and Cosmology PoS(CompTools2021), 409 034, 2022
- [6] E. M. Abenavoli et al., Characterization of mediastinal bulky lymphomas with FDG-PET-based radiomics and machine learning techniques, in preparation for Cancers
- [7] LHCb Collaboration, Measurement of antiproton production from antihyperon decays in pHe collisions at $\sqrt{s_{\mathrm{NN}}} = 110$ GeV, arXiv:2205.09009

CONTRIBUTIONS TO OPEN SOURCE SOFTWARE

landerlini/hopaas 🏶

JAVASCRIPT, PYTHON, HTML

Multi-nodes hyperparameter optimization campaigns submitting queries to a central, managed service

landerlini/hopaas client 😱

Python

Python front-end to ease the access to the Hopaas service

mbarbetti/tf-gen-models 🕠 🕏

JUPYTER NOTEBOOK, PYTHON

Ready to use implementations of state-of-the-art generative models in TensorFlow 2

mbarbetti/lb-pidsim-train 🜍 🏺

Python

Scripts and logics to train PID models for the Ultra-Fast Simulation of the LHCb experiment

landerlini/scikinC 🖓 🅏

Python

A converter for Scikit-Learn and Keras to hardcoded C function

alshedivat/al-folio 🏶 🖓 👛

HTML, JAVASCRIPT

A beautiful, simple, clean, and responsive Jekyll theme for academics

landerlini/mlinfn-advanced-hackathon 🗘

Jupyter Notebook

Notebooks and code for the ML INFN Advanced Hackathon events

mbarbetti/lymphoma-classification 🖓

JUPYTER NOTEBOOK, PYTHON

Bulky mediastinal lymphoma classification with machine learning techniques

mbarbetti/optunapi 🜍 🍨

Python

Simple API to distribute hyperparameter optimization through HTTP requests

COMPUTER SKILLS

LANGUAGES

GitHub	https://github.com/mbarbetti	Italian	Native
Languages	Python, HTML, $C/C++$, TeX	English	Advanced
\mathbf{OS}	Mac OS, Windows, Linux	Spanish	Intermediate