

MATTEO BARBETTI

Ph.D. student in Smart Computing

Department of Physics and Astronomy, University of Florence

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INTERESTS

machine-learning, deep-generative-models, optimization-studies, bayesian-optimization, high-energy-physics, detector-simulation, parametric-simulation, ultrafast-simulation

EDUCATION

University of Florence

Firenze, Italy

🎓 PH.D. IN SMART COMPUTING

Nov 2020 – present

Topic: *Smart Computing Techniques applied to Medical Physics, Nuclear Physics and Particle Physics*

Advisors: Lucio Anderlini, Denis Derkach, Michael Williams

University of Florence

Firenze, Italy

🎓 M.SC. IN PARTICLE PHYSICS

Sep 2017 – Jun 2020

Thesis: *“Techniques for parametric simulation with deep neural networks and implementation for the LHCb experiment at CERN and its future upgrades”*

Thesis Advisors: Lucio Anderlini, Piergiulio Lenzi

Graduation Score: 110/110 *cum laude*

University of Florence

Firenze, Italy

🎓 B.SC. IN PHYSICS AND ASTROPHYSICS

Sep 2013 – Sep 2017

Thesis: *“Study of the charmonium resonances in $B^+ \rightarrow p\bar{p}K^+$ and $B^+ \rightarrow p\bar{p}\gamma K^+$ decays with the LHCb experiment at CERN”*

Thesis Advisors: Lucio Anderlini, Giuseppe Latino

Graduation Score: 110/110

EXPERIENCE

University of Florence

Firenze, Italy

GRADUATE RESEARCHER (LHCb Florence Group)

Nov 2020 – present

📖 *Research focused on development and deployment of Ultra-Fast Simulation for LHCb, generative models optimization and parallel computing for intense hyperparameter studies.*

Advisor: Lucio Anderlini

INFN-Firenze

Firenze, Italy

STUDENT RESEARCHER

Feb 2020 – Apr 2020

📖 *Traineeship focused on application of machine learning techniques to High Energy Physics.*

Tutors: Gabriele Pasquali, Lucio Anderlini

CERN

Geneva, Switzerland

RESEARCH INTERN (LHCb Experiment)

Sep 2019 – Dec 2019

📖 *Research in generative models to parameterise the LHCb particle identification system.*

Host: Giovanni Passaleva

University of Florence

Firenze, Italy

STUDENT RESEARCHER (LHCb Florence Group)

Jun 2019 – Jun 2020

📄 *Research aimed to build (non)parametric models for the LHCb detector and to develop a new simulation framework for High Energy Physics applications.*

Mentors: Lucio Anderlini, Giacomo Graziani

CERN

Geneva, Switzerland

STUDENT RESEARCHER (LHCb Experiment)

Jul 2017

📄 *Research in statistical methods for data analysis in High Energy Physics.*

Host: Giovanni Passaleva

University of Florence

Firenze, Italy

STUDENT RESEARCHER (LHCb Florence Group)

May 2017 – Sep 2017

📄 *Research aimed to study charmonium resonances decaying into purely hadronic final states as reconstructed by the LHCb experiment.*

Mentors: Lucio Anderlini, Giacomo Graziani

HONORS & AWARDS**“Giulia Vita Finzi” award**, INFN

2022

🏆 *National INFN award for the best Master Thesis (Jun 2020 – May 2021) on computing and networks*

Ph.D. Scholarship in Smart Computing, INFN

2020 – 2023

🏆 *Scholarship to carry out Machine Learning research for Physics applications*

Scholarship for research activity, INFN

2019

🏆 *National grant to pass three months at CERN for research activity*

Scholarship for thesis abroad, University of Florence

2017

🏆 *Local grant to pass ten days at CERN for bachelor thesis*

CONFERENCES, WORKSHOPS & SCHOOLS**108° Congresso Nazionale della SIF**

Milan, Italy

Italian Physical Society (SIF)

Sep 2022

Oral: “*ML in the histological differentiation of mediastinal bulky lymphoma*”

**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**

Orsay, France

Institut Pascal Paris-Saclay

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

Italian Physical Society (SIF)

Sep 2021

Oral: “*Simulating the LHCb detector with GANs*”



8th Thematic CERN School of Computing

CERN School of Computing

Theme: *Scientific Software for Heterogeneous Architectures* (participant)

online

Jun 2021

**Workshop della Commissione Calcolo e Reti dell'INFN**

INFN Computing and Network Service

Oral: *"Simulating the LHCb detector with GANs"*

online

May 2021

**1st CloudBank EU Workshop**

CERN IT and IPT Departments

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

online

Apr 2021

**OPEN SOURCE SOFTWARE**

Hopaas

JAVASCRIPT, PYTHON, HTML

Hyperparameter optimization as a service

**TorchGen**

PYTHON

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

**TFGenModels**

PYTHON

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

**lb-pidsim-train**

PYTHON

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

**lymphoma-classification**

JUPYTER NOTEBOOK, PYTHON

Bulky mediastinal lymphoma classification with machine learning techniques

**OptunAPI**

PYTHON

API to distribute hyperparameters optimization through HTTP requests

**PUBLICATIONS**

*Papers reported in reverse chronological order***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**, in preparation
- [2] E. M. Abenavoli *et al.*, *Characterization of mediastinal bulky lymphomas with FDG-PET-based radiomics and machine learning techniques*, submitted to **Leukemia and Lymphoma**
- [3] 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**
- [4] 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**

Preprints & Working Papers

- [1] E. M. Abenavoli *et al.*, *Characterization of mediastinal bulky lymphomas with FDG-PET-based radiomics and machine learning techniques*, submitted to [Leukemia and Lymphoma](#)
- [2] LHCb Collaboration, *Measurement of the Λ_c^+ to D^0 production cross-section ratio in peripheral PbPb collisions*, [arXiv:2210.06939](#)
- [3] LHCb Collaboration, *Search for the lepton-flavour violating decays $B^0 \rightarrow K^{*0}\tau^\pm\mu^\mp$* , [arXiv:2209.09846](#)
- [4] LHCb Collaboration, *Amplitude analysis of the $D_s^+ \rightarrow \pi^-\pi^+\pi^+$ decay*, [arXiv:2209.09840](#)
- [5] LHCb Collaboration, *Measurement of the CKM angle γ with $B^\pm \rightarrow D [K^\mp\pi^\pm\pi^\pm\pi^\mp] h^\pm$ decays using a binned phase-space approach*, [arXiv:2209.03692](#)
- [6] LHCb Collaboration, *Measurement of the time-integrated CP asymmetry in $D^0 \rightarrow K^-K^+$ decays*, [arXiv:2209.03179](#)
- [7] LHCb Collaboration, *Multidifferential study of identified charged hadron distributions in Z-tagged jets in proton-proton collisions at $\sqrt{s}=13$ TeV*, [arXiv:2208.11691](#)
- [8] LHCb Collaboration, *Study of B_c^+ meson decays to charmonia plus multihadron final states*, [arXiv:2208.08660](#)
- [9] LHCb Collaboration, *Model-independent measurement of charm mixing parameters in $\bar{B} \rightarrow D^0(\rightarrow K_S^0\pi^+\pi^-)\mu^-\bar{\nu}_\mu X$* , [arXiv:2208.06512](#)
- [10] LHCb Collaboration, *Amplitude analysis of the $D^+ \rightarrow \pi^-\pi^+\pi^+$ decay and measurement of the $\pi^-\pi^+$ S-wave amplitude*, [arXiv:2208.03300](#)
- [11] LHCb Collaboration, *Amplitude analysis of the $\Lambda_c^+ \rightarrow pK^-\pi^+$ decay and Λ_c^+ baryon polarization measurement in semileptonic beauty hadron decays*, [arXiv:2208.03262](#)
- [12] LHCb Collaboration, *Search for the lepton-flavour violating decays $B^0 \rightarrow K^{*0}\mu^\pm e^\mp$ and $B_s^0 \rightarrow \phi\mu^\pm e^\mp$* , [arXiv:2207.04005](#)
- [13] LHCb Collaboration, *Study of coherent charmonium production in ultra-peripheral lead-lead collisions*, [arXiv:2206.08221](#)
- [14] LHCb Collaboration, *Direct CP violation in charmless three-body decays of B^\pm mesons*, [arXiv:2206.07622](#)
- [15] LHCb Collaboration, *Search for the rare hadronic decay $B_s^0 \rightarrow p\bar{p}$* , [arXiv:2206.06673](#)
- [16] LHCb Collaboration, *Measurement of τ_L using the $B_s^0 \rightarrow J/\psi\eta$ decay mode*, [arXiv:2206.03088](#)
- [17] LHCb Collaboration, *Search for direct CP violation in charged charmless $B \rightarrow PV$ decays*, [arXiv:2206.02038](#)
- [18] LHCb Collaboration, *Measurement of the Z boson production cross-section in proton-lead collisions at $\sqrt{s_{NN}} = 8.16$ TeV*, [arXiv:2205.10213](#)
- [19] LHCb Collaboration, *Measurement of antiproton production from antihyperon decays in pHe collisions at $\sqrt{s_{NN}} = 110$ GeV*, [arXiv:2205.09009](#)
- [20] LHCb Collaboration, *Search for CP violation using \hat{T} -odd correlations in $B^0 \rightarrow p\bar{p}K^+\pi^-$ decays*, [arXiv:2205.08973](#)
- [21] LHCb Collaboration, *Measurement of the prompt D^0 nuclear modification factor in pPb collisions at $\sqrt{s_{NN}} = 8.16$ TeV*, [arXiv:2205.03936](#)

- [22] LHCb Collaboration, *Evidence for modification of b quark hadronization in high-multiplicity pp collisions at $\sqrt{s} = 13$ TeV*, [arXiv:2204.13042](#)
- [23] LHCb Collaboration, *Observation of sizeable ω contribution to $\chi_{c1}(3872) \rightarrow \pi^+\pi^- J/\psi$ decays*, [arXiv:2204.12597](#)
- [24] LHCb Collaboration, *Measurement of CP asymmetries in $D_{(s)}^+ \rightarrow \eta\pi^+$ and $D_{(s)}^+ \rightarrow \eta'\pi^+$ decays*, [arXiv:2204.12228](#)
- [25] LHCb Collaboration, *Nuclear modification factor of neutral pions in the forward and backward regions in pPb collisions*, [arXiv:2204.10608](#)
- [26] 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](#)
- [27] LHCb Collaboration, *Search for the doubly heavy baryon Ξ_{bc}^+ decaying to $J/\psi\Xi_c^+$* , [arXiv:2204.09541](#)

Conference & Journal Articles

- [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**, in preparation
- [2] LHCb Collaboration, R. Aaij *et al.*, *First measurement of the $Z \rightarrow \mu^+\mu^-$ angular coefficients in the forward region of pp collisions at $\sqrt{s} = 13$ TeV*, *Phys. Rev. Lett.* **129** (2022) 091801, [arXiv:2203.01602](#)
- [3] LHCb Collaboration, R. Aaij *et al.*, *Constraints on the CKM angle γ from $B^\pm \rightarrow Dh^\pm$ decays using $D \rightarrow h^\pm h'^\mp \pi^0$ final states*, *JHEP* **07** (2022) 099, [arXiv:2112.10617](#)
- [4] 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
- [5] LHCb Collaboration, R. Aaij *et al.*, *Precision measurement of forward Z boson production in proton-proton collisions at $\sqrt{s} = 13$ TeV*, *JHEP* **07** (2022) 026, [arXiv:2112.07458](#)
- [6] LHCb Collaboration, R. Aaij *et al.*, *Study of the doubly charmed tetraquark T_{cc}^+* , *Nat. Commun.* **13** (2022) 3351, [arXiv:2109.01056](#)
- [7] LHCb Collaboration, R. Aaij *et al.*, *Observation of an exotic narrow doubly charmed tetraquark*, *Nat. Phys.* (2022), [arXiv:2109.01038](#)
- [8] LHCb Collaboration, R. Aaij *et al.*, *Angular analysis of $D^0 \rightarrow \pi^+\pi^-\mu^+\mu^-$ and $D^0 \rightarrow K^+K^-\mu^+\mu^-$ decays and search for CP violation*, *Phys. Rev. Lett.* **128** (2022) 221801, [arXiv:2111.03327](#)
- [9] LHCb Collaboration, R. Aaij *et al.*, *Measurement of the charm mixing parameter $y_{CP} - y_{CP}^{K\pi}$ using two-body D^0 meson decays*, *Phys. Rev. D* **105** (2022) 092013, [arXiv:2202.09106](#)
- [10] LHCb Collaboration, R. Aaij *et al.*, *Observation of the decay $\Lambda_b^0 \rightarrow \Lambda_c^+ \tau^- \bar{\nu}_\tau$* , *Phys. Rev. Lett.* **128** (2022) 191803, [arXiv:2201.03497](#)
- [11] LHCb Collaboration, R. Aaij *et al.*, *Tests of lepton universality using $B^0 \rightarrow K_S^0 \ell^+ \ell^-$ and $B^+ \rightarrow K^{*+} \ell^+ \ell^-$ decays*, *Phys. Rev. Lett.* **128** (2022) 191802, [arXiv:2110.09501](#)
- [12] LHCb Collaboration, R. Aaij *et al.*, *Search for the decay $B^0 \rightarrow \phi \mu^+ \mu^-$* , *JHEP* **05** (2022) 067, [arXiv:2201.10167](#)

- [13] LHCb Collaboration, R. Aaij *et al.*, *Observation of the doubly charmed baryon decay $\Xi_{cc}^{++} \rightarrow \Xi_c'^+ \pi^+$* , **JHEP** **05** (2022) 038, [arXiv:2202.05648](#)
- [14] LHCb Collaboration, R. Aaij *et al.*, *Search for massive long-lived particles decaying semileptonically at $\sqrt{s} = 13$ TeV*, **Eur. Phys. J. C** **82** (2022) 373, [arXiv:2110.07293](#)
- [15] LHCb Collaboration, R. Aaij *et al.*, *Observation of two new excited Ξ_b^0 states decaying to $\Lambda_b^0 K^- \pi^+$* , **Phys. Rev. Lett.** **128** (2022) 162001, [arXiv:2110.04497](#)
- [16] LHCb Collaboration, R. Aaij *et al.*, *Observation of the $B^0 \rightarrow \bar{D}^{*0} K^+ \pi^-$ and $B_s^0 \rightarrow \bar{D}^{*0} K^- \pi^+$ decays*, **Phys. Rev. D** **105** (2022) 072005, [arXiv:2112.11428](#)
- [17] LHCb Collaboration, R. Aaij *et al.*, *Study of charmonium and charmonium-like contributions in $B^+ \rightarrow J/\psi \eta K^+$ decays*, **JHEP** **04** (2022) 046, [arXiv:2202.04045](#)
- [18] LHCb Collaboration, R. Aaij *et al.*, *Measurement of the photon polarization in $\Lambda_b \rightarrow \Lambda \gamma$ decays*, **Phys. Rev. D** **105** (2022) L051104, [arXiv:2111.10194](#)
- [19] LHCb Collaboration, R. Aaij *et al.*, *Observation of $\Lambda_b^0 \rightarrow D^+ p \pi^- \pi^-$ and $\Lambda_b^0 \rightarrow D^{*+} p \pi^- \pi^-$ decays*, **JHEP** **03** (2022) 153, [arXiv:2112.02013](#)
- [20] LHCb Collaboration, R. Aaij *et al.*, *Searches for rare B_s^0 and B^0 decays into four muons*, **JHEP** **03** (2022) 109, [arXiv:2111.11339](#)
- [21] LHCb Collaboration, R. Aaij *et al.*, *Measurement of the lifetimes of promptly produced Ω_c^0 and Ξ_c^0 baryons*, **Sci. Bull.** **67** (2022) 5, [arXiv:2109.01334](#)
- [22] LHCb Collaboration, R. Aaij *et al.*, *Study of Z bosons produced in association with charm in the forward region*, **Phys. Rev. Lett.** **128** (2022) 082001, [arXiv:2109.08084](#)
- [23] LHCb Collaboration, R. Aaij *et al.*, *Identification of charm jets at LHCb*, **JINST** **17** (2022) P02028, [arXiv:2112.08435](#)
- [24] LHCb Collaboration, R. Aaij *et al.*, *Measurement of $\chi_{c1}(3872)$ production in proton-proton collisions at $\sqrt{s} = 8$ and 13 TeV*, **JHEP** **01** (2022) 131, [arXiv:2109.07360](#)
- [25] LHCb Collaboration, R. Aaij *et al.*, *Study of the B_c^+ decays into charmonia and three light hadrons*, **JHEP** **01** (2022) 065, [arXiv:2111.03001](#)
- [26] LHCb Collaboration, R. Aaij *et al.*, *Measurement of the W boson mass*, **JHEP** **01** (2022) 036, [arXiv:2109.01113](#)
- [27] LHCb Collaboration, R. Aaij *et al.*, *Observation of the suppressed $\Lambda_b^0 \rightarrow D p K^-$ decay with $D \rightarrow K^+ \pi^-$ and measurement of its CP asymmetry*, **Phys. Rev. D** **104** (2021) 112008, [arXiv:2109.02621](#)
- [28] LHCb Collaboration, R. Aaij *et al.*, *Simultaneous determination of CKM angle γ and charm mixing parameters*, **JHEP** **12** (2021) 141, [arXiv:2110.02350](#)
- [29] LHCb Collaboration, R. Aaij *et al.*, *Updated search for B_c^+ decays to two charm mesons*, **JHEP** **12** (2021) 117, [arXiv:2109.00488](#)
- [30] LHCb Collaboration, R. Aaij *et al.*, *Search for the doubly charmed baryon Ξ_{cc}^+ in the $\Xi_c^+ \pi^- \pi^+$ final state*, **JHEP** **12** (2021) 107, [arXiv:2109.07292](#)
- [31] LHCb Collaboration, R. Aaij *et al.*, *Measurement of J/ψ production cross-sections in pp collisions at $\sqrt{s} = 5$ TeV*, **JHEP** **11** (2021) 181, [arXiv:2109.00220](#)
- [32] LHCb Collaboration, R. Aaij *et al.*, *Angular analysis of the rare decay $B_s^0 \rightarrow \phi \mu^+ \mu^-$* , **JHEP** **11** (2021) 043, [arXiv:2107.13428](#)

TEACHING & TUTORING

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

- B015862: Physics Laboratory III – *Head TA for Vitaliano Ciulli* 2022 – 2023
- B015861: Physics Laboratory II – *Lab Tutor for Marco Capitanio* 2022 – 2023
- B015862: Physics Laboratory III – *Lab Tutor and Head TA for Vitaliano Ciulli* 2021
- B015861: Physics Laboratory II – *Lab Tutor for Andrea Stefanini* 2021
- B015860: Physics Laboratory I – *Lab Tutor and TA for Massimo Bongì* 2021
- B005476: Physics I – *TA for Oscar Adriani* 2021
- B015860: Physics Laboratory I – *Lab Tutor and TA for Massimo Bongì* 2019 – 2020
- B005476: Physics I – *TA for Oscar Adriani* 2019 – 2020

B.Sc. in Mathematics, University of Florence

- B016237: Physics II with Laboratory – *Lab Tutor and TA for Piergiulio Lenzi* 2022 – 2023
- B016236: Physics I with Laboratory – *Lab Tutor and TA for Andrea Stefanini* 2022 – 2023
- B016237: Physics II with Laboratory – *Lab Tutor and TA for Piergiulio Lenzi* 2021

B.Sc. in Biological Sciences, University of Florence

- B019238: Physics Laboratory for Biology – *Lab Tutor and TA for Francesca Intonti* 2019 – 2020
- B019238: Physics Laboratory for Biology – *Lab Tutor and TA for Francesca Intonti* 2018 – 2019
- B019231: Physics – *TA for Diederik Sybolt Wiersma* 2018 – 2019

OUTREACH & DISSEMINATION

Science book “Invenzioni”

Sassi Junior & INFN

Preparation of a paragraph dedicated to Artificial Intelligence

Jun 2021



Live interview “Fisica del Clima” with Daniele Visioni

AISF & Cornell University

Organization of an interview about Climate Physics

online

Mar 2021



Live interview “Women in Science” with Anna Gregorio

AISF & University of Trieste

Organization of an interview on the occasion of Women in Science International Day

online

Feb 2021



Live interview “COVID19” with Eugenio Valdano

AISF & INSERM

Organization of an interview about statistical models for COVID-19 pandemic

online

Apr 2020



Outreach event “Tra clima e cocktail”

AISF, Italian Climate Network, CNR & University of Florence

Organization of an event aimed to raise awareness about climate change problem

Firenze, Italy

May 2019



Outreach event “Viaggio al Polo”

AISF, Caffè-Scienza, INFN & University of Florence

Organization of an event about intelligence according to various scientific domains

Firenze, Italy

May 2019



Outreach event “Luminoscienza”

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

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

Firenze, Italy

May 2018



Seminar “The new particles of LHCb” by Lucio Anderlini

AISF & LHCb Florence Group

Organization of a seminar to discuss latest LHCb discoveries

Firenze, Italy

Oct 2017

**LEADERSHIP & COMMUNITY SERVICES**

National Institute for Nuclear Physics (INFN)

- PhD Student Member
- Master Student Member



Nov 2020 – present

Sep 2019 – Jun 2020

LHCb Collaboration

- PhD Student Author
- LHCb DQCS shifter
- PhD Student Member
- Master Student Member
- Bachelor Student Member



May 2021 – present

Mar 2021 – present

Nov 2020 – present

Sep 2019 – Jun 2020

Jul 2017 – Sep 2017

Italian Association of Physics Students (AISF)

- Deputy-President
- Secretary
- President of the Florence Local Committee
- Editorial Board Member of “Sistemi di Riferimento”
- Deputy-President of the Florence Local Committee



Oct 2020 – Sep 2021

Oct 2019 – Sep 2021

Nov 2018 – May 2019

May 2018 – Sep 2021

Dec 2017 – Nov 2018

COMPUTER SKILLS

GitHub <https://github.com/mbarbetti>
Languages Python, HTML, C/C++, TeX
OS Windows, Mac OS, Linux

LANGUAGES

Italian *Native*
English *Advanced*
Spanish *Intermediate*