Matteo Barbetti

Ph.D. student in Smart Computing

Department of Physics and Astronomy, University of Florence
Room 183, Via Sansone 1, 50019 Sesto Fiorentino (FI), Italy

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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 $B^+ \to p\bar{p}K^+$ and $B^+ \to p\bar{p}\gamma K^+$ 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

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

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 online
CERN School of Computing Jun 2021
Theme: *Scientific Software for Heterogeneous Architectures* (participant)

Workshop della Commissione Calcolo e Reti dell'INFN online
INFN Computing and Network Service May 2021
Oral: *"Simulating the LHCb detector with GANs"*

1st CloudBank EU Workshop online
CERN IT and IPT Departments Apr 2021
Oral: *"LHCb deployment in AWS"* (restricted access)

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] 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** (2022) 167591

[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] 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 ratio of branching fractions* $\mathcal{B}(B_c^+ \to B_s^0\pi^+)/\mathcal{B}(B_c^+ \to J/\psi\pi^+)$, arXiv:2210.12000

[3] LHCb Collaboration, *Search for the baryon- and lepton-number violating decays* $B^0 \to p\mu^-$ *and* $B_s^0 \to p\mu^-$, arXiv:2210.10412

[4] LHCb Collaboration, *Observation of a* $J/\psi\Lambda$ *resonance consistent with a strange pentaquark candidate in* $B^- \to J/\psi\Lambda\bar{p}$ *decays*, arXiv:2210.10346

[5] LHCb Collaboration, *Measurement of the* Λ_c^+ *to* D^0 *production cross-section ratio in peripheral PbPb collisions*, arXiv:2210.06939

[6] LHCb Collaboration, *Search for the lepton-flavour violating decays* $B^0 \to K^{*0}\tau^\pm\mu^\mp$, arXiv:2209.09846

[7] LHCb Collaboration, *Amplitude analysis of the* $D_s^+ \to \pi^-\pi^+\pi^+$ *decay*, arXiv:2209.09840

[8] LHCb Collaboration, *Measurement of the CKM angle* γ *with* $B^\pm \to D\,[K^\mp\pi^\pm\pi^\pm\pi^\mp]\,h^\pm$ *decays using a binned phase-space approach*, arXiv:2209.03692

[9] LHCb Collaboration, *Measurement of the time-integrated* CP *asymmetry in* $D^0 \to K^-K^+$ *decays*, arXiv:2209.03179

[10] 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

[11] LHCb Collaboration, *Study of* B_c^+ *meson decays to charmonia plus multihadron final states*, arXiv:2208.08660

[12] LHCb Collaboration, *Model-independent measurement of charm mixing parameters in* $\bar{B} \to D^0(\to K_S^0\pi^+\pi^-)\mu^-\bar{\nu}_\mu X$, arXiv:2208.06512

[13] LHCb Collaboration, *Amplitude analysis of the* $D^+ \to \pi^-\pi^+\pi^+$ *decay and measurement of the* $\pi^-\pi^+$ *S-wave amplitude*, arXiv:2208.03300

[14] LHCb Collaboration, *Amplitude analysis of the* $\Lambda_c^+ \to pK^-\pi^+$ *decay and* Λ_c^+ *baryon polarization measurement in semileptonic beauty hadron decays*, arXiv:2208.03262

[15] LHCb Collaboration, *Search for the lepton-flavour violating decays* $B^0 \to K^{*0}\mu^\pm e^\mp$ *and* $B_s^0 \to \phi\mu^\pm e^\mp$, arXiv:2207.04005

[16] LHCb Collaboration, *Study of coherent charmonium production in ultra-peripheral lead-lead collisions*, arXiv:2206.08221

[17] LHCb Collaboration, *Direct* CP *violation in charmless three-body decays of* $B^\pm$ *mesons*, arXiv:2206.07622

[18] LHCb Collaboration, *Search for the rare hadronic decay* $B_s^0 \to p\bar{p}$, arXiv:2206.06673

[19] LHCb Collaboration, *Measurement of τ_L using the $B_s^0 \to J/\psi\eta$ decay mode*, arXiv:2206.03088

[20] LHCb Collaboration, *Search for direct CP violation in charged charmless $B \to PV$ decays*, arXiv:2206.02038

[21] LHCb Collaboration, *Measurement of the Z boson production cross-section in proton-lead collisions at $\sqrt{s_{\rm NN}} = 8.16$ TeV*, arXiv:2205.10213

[22] LHCb Collaboration, *Measurement of antiproton production from antihyperon decays in pHe collisions at $\sqrt{s_{\rm NN}} = 110$ GeV*, arXiv:2205.09009

[23] LHCb Collaboration, *Search for CP violation using $\hat{T}$-odd correlations in $B^0 \to p\bar{p}K^+\pi^-$ decays*, arXiv:2205.08973

[24] LHCb Collaboration, *Measurement of the prompt D^0 nuclear modification factor in pPb collisions at $\sqrt{s_{\rm NN}} = 8.16$ TeV*, arXiv:2205.03936

[25] LHCb Collaboration, *Evidence for modification of b quark hadronization in high-multiplicity pp collisions at $\sqrt{s} = 13$ TeV*, arXiv:2204.13042

[26] LHCb Collaboration, *Observation of sizeable ω contribution to $\chi_{c1}(3872) \to \pi^+\pi^- J/\psi$ decays*, arXiv:2204.12597

[27] LHCb Collaboration, *Measurement of CP asymmetries in $D^+_{(s)} \to \eta\pi^+$ and $D^+_{(s)} \to \eta'\pi^+$ decays*, arXiv:2204.12228

[28] LHCb Collaboration, *Nuclear modification factor of neutral pions in the forward and backward regions in pPb collisions*, arXiv:2204.10608

[29] 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

[30] 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] 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** (2022) 167591

[3] LHCb Collaboration, R. Aaij *et al.*, *First measurement of the $Z \to \mu^+\mu^-$ angular coefficients in the forward region of pp collisions at $\sqrt{s} = 13$ TeV*, Phys. Rev. Lett. **129** (2022) 091801, arXiv:2203.01602

[4] LHCb Collaboration, R. Aaij *et al.*, *Constraints on the CKM angle γ from $B^\pm \to Dh^\pm$ decays using $D \to h^\pm h'^\mp \pi^0$ final states*, JHEP **07** (2022) 099, arXiv:2112.10617

[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] 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

[7] LHCb Collaboration, R. Aaij *et al.*, *Study of the doubly charmed tetraquark T_{cc}^+*, Nat. Commun. **13** (2022) 3351, arXiv:2109.01056

[8] LHCb Collaboration, R. Aaij *et al.*, *Observation of an exotic narrow doubly charmed tetraquark*, Nat. Phys. (2022), arXiv:2109.01038

[9] LHCb Collaboration, R. Aaij *et al.*, *Angular analysis of* $D^0 \to \pi^+\pi^-\mu^+\mu^-$ *and* $D^0 \to K^+K^-\mu^+\mu^-$ *decays and search for* CP *violation*, Phys. Rev. Lett. **128** (2022) 221801, arXiv:2111.03327

[10] 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

[11] LHCb Collaboration, R. Aaij *et al.*, *Observation of the decay* $\Lambda_b^0 \to \Lambda_c^+\tau^-\overline{\nu}_\tau$, Phys. Rev. Lett. **128** (2022) 191803, arXiv:2201.03497

[12] LHCb Collaboration, R. Aaij *et al.*, *Tests of lepton universality using* $B^0 \to K_S^0\ell^+\ell^-$ *and* $B^+ \to K^{*+}\ell^+\ell^-$ *decays*, Phys. Rev. Lett. **128** (2022) 191802, arXiv:2110.09501

[13] LHCb Collaboration, R. Aaij *et al.*, *Search for the decay* $B^0 \to \phi\mu^+\mu^-$, JHEP **05** (2022) 067, arXiv:2201.10167

[14] LHCb Collaboration, R. Aaij *et al.*, *Observation of the doubly charmed baryon decay* $\Xi_{cc}^{++} \to \Xi_c^{\prime+}\pi^+$, JHEP **05** (2022) 038, arXiv:2202.05648

[15] 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

[16] 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

[17] LHCb Collaboration, R. Aaij *et al.*, *Observation of the* $B^0 \to \overline{D}^{*0}K^+\pi^-$ *and* $B_s^0 \to \overline{D}^{*0}K^-\pi^+$ *decays*, Phys. Rev. D **105** (2022) 072005, arXiv:2112.11428

[18] LHCb Collaboration, R. Aaij *et al.*, *Study of charmonium and charmonium-like contributions in* $B^+ \to J/\psi\eta K^+$ *decays*, JHEP **04** (2022) 046, arXiv:2202.04045

[19] LHCb Collaboration, R. Aaij *et al.*, *Measurement of the photon polarization in* $\Lambda_b \to \Lambda\gamma$ *decays*, Phys. Rev. D **105** (2022) L051104, arXiv:2111.10194

[20] LHCb Collaboration, R. Aaij *et al.*, *Observation of* $\Lambda_b^0 \to D^+p\pi^-\pi^-$ *and* $\Lambda_b^0 \to D^{*+}p\pi^-\pi^-$ *decays*, JHEP **03** (2022) 153, arXiv:2112.02013

[21] 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

[22] 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

[23] 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

[24] LHCb Collaboration, R. Aaij *et al.*, *Identification of charm jets at LHCb*, JINST **17** (2022) P02028, arXiv:2112.08435

[25] 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

[26] 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

[27] LHCb Collaboration, R. Aaij *et al.*, *Measurement of the* W *boson mass*, JHEP **01** (2022) 036, arXiv:2109.01113

[28] LHCb Collaboration, R. Aaij *et al.*, *Observation of the suppressed* $\Lambda_b^0 \to DpK^-$ *decay with* $D \to K^+\pi^-$ *and measurement of its CP asymmetry*, Phys. Rev. D **104** (2021) 112008, arXiv:2109.02621

[29] LHCb Collaboration, R. Aaij *et al.*, *Simultaneous determination of CKM angle* γ *and charm mixing parameters*, JHEP **12** (2021) 141, arXiv:2110.02350

[30] LHCb Collaboration, R. Aaij *et al.*, *Updated search for* B_c^+ *decays to two charm mesons*, JHEP **12** (2021) 117, arXiv:2109.00488

[31] 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

[32] 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

[33] LHCb Collaboration, R. Aaij *et al.*, *Angular analysis of the rare decay* $B_s^0 \to \phi\mu^+\mu^-$, 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 Bongi* 2021
- B005476: Physics I – *TA for Oscar Adriani* 2021
- B015860: Physics Laboratory I – *Lab Tutor and TA for Massimo Bongi* 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 Jun 2021
Preparation of a paragraph dedicated to Artificial Intelligence

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
AISF & University of Trieste Feb 2021
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
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
Organization of an event about intelligence according to various scientific domains

Outreach event "Luminoscienza" Firenze, Italy
AISF, LENS, University of Florence, INRIM & Caffè-Scienza May 2018
Organization of three scientific evenings on the occasion of International Day of Light

Seminar "The new particles of LHCb" by Lucio Anderlini Firenze, Italy
AISF & LHCb Florence Group Oct 2017
Organization of a seminar to discuss latest LHCb discoveries

Leadership & Community Services

National Institute for Nuclear Physics (INFN)
- PhD Student Member — Nov 2020 – present
- Master Student Member — Sep 2019 – Jun 2020

LHCb Collaboration
- PhD Student Author — May 2021 – present
- LHCb DQCS shifter — Mar 2021 – present
- PhD Student Member — Nov 2020 – present
- Master Student Member — Sep 2019 – Jun 2020
- Bachelor Student Member — Jul 2017 – Sep 2017

Italian Association of Physics Students (AISF)
- Deputy-President — Oct 2020 – Sep 2021
- Secretary — Oct 2019 – Sep 2021
- President of the Florence Local Committee — Nov 2018 – May 2019
- Editorial Board Member of "Sistemi di Riferimento" — May 2018 – Sep 2021
- Deputy-President of the Florence Local Committee — 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*