Alessandro Barone

Postdoctoral Researcher | Computational & Theoretical Particle Physics

abarone@uni-mainz.de · ale-barone.github.io · ale-barone

Profile

Computational and theoretical physicist with 7+ years of experience in research software development and high-performance computing for large-scale simulations in particle physics, specifically lattice quantum chromodynamics (lattice QCD). Strong background in numerical methods, statistical data analysis, inverse problems, and algorithm development. Experienced in C++/Python software development, HPC workflow design, management of multi-TB datasets, reproducible pipelines, and international collaboration.

Research Interests & Skills

Interests	Lattice Field Theory, QCD, Hadron Structure, Heavy Quarks, Algorithms
Programming	Python, C++, Bash, Git, HPC (SLURM, PBS), containers (Docker), unit testing, documentation
Languages	Italian (native), English (C1), French (C1)

Work Experience

2023 – now **Postdoctoral Researcher** — Johannes Gutenberg University Mainz

- Led the theoretical calculation of the proton–neutron electromagnetic mass splitting from first principle. PI for an HPC allocation (PC2, 2026-2027; 28 MCPU-hours, 160 TB storage), overseeing data generation and analysis.
- Led the calculation of the axial form factor of the nucleon from large-scale lattice QCD simulations. Responsible for the processing of multi-TB datasets, the development of Python data analysis pipelines and final publication.
- Co-led a major HPC resource allocation proposal for precision heavy-quark physics (DiRAC, 2025–2027; 2 MGPU-hours, 100 TB storage), with responsibility for workflow planning, data management strategy, and reproducible end-to-end data analysis pipelines from simulation to publication.

2019 – 2023 **Doctoral Researcher & Teaching Assistant** — University of Southampton

- Led an end-to-end computational research project on inclusive semileptonic $B_{(s)}$-meson decays from first principles, from theoretical formulation and numerical implementation to publication. Developed the full workflow, including theoretical design, large-scale data generation, and statistical analysis in Python, laying the methodological basis for a first-of-its-kind calculation.
- Developed and validated new C++ modules within the open-source `Hadrons` framework, a large-scale `Grid`-based workflow management system for lattice QCD simulations with users across Europe, Japan, and the US; outputs cross-validated against an independent codebase.
- Teaching assistant (Statistical Mechanics, Nuclei and Particles).

09/2019 – 03/2020 **External Collaborator (Technical Writer)** — Zanichelli editore S.p.A, Italy

- Wrote structured solutions for physics exercises across three high-school mathematics textbooks for a leading Italian academic publisher. Translated technical content into clear, accessible explanations.

Education

2019 – 2023 **PhD, Theoretical Particle Physics** — University of Southampton

Thesis: *Inclusive semileptonic $B_{(s)}$-meson decays from lattice QCD*, supervised by Prof. Andreas Jüttner (now staff at CERN). Member of the RBC/UKQCD collaboration. Four-month research visit at KEK (Tsukuba, Japan) as JSPS fellow under the supervision of Prof. Shoji Hashimoto.

2016 – 2019 **Master's Degree, Theoretical Physics** (110/110 *cum laude*) — University of Bologna

Thesis: *The cosmological moduli problem in multi-field string inflationary models*, supervised by Prof. Michele Cicoli.

2016 – 2019 **Diploma in Interdisciplinary Studies, Collegio Superiore** — University of Bologna

Selective excellence programme ($\sim$20 students per year across all disciplines), offering courses of high qualification and interdisciplinary value supplementary to those of the degree courses.

2013 – 2016 **Bachelor's Degree, Physics** (110/110 *cum laude*) — University of Pavia

Thesis: *Hadronic physics: from the quark model to QCD*, supervised by Prof. Daniela Rebuzzi.

Scholarships and Awards

2022 **JSPS Short-Term Fellowship for Research in Japan** — JSPS, Japan
Competitive international fellowship to conduct research at KEK (Tsukuba) for four months (1M JPY $\simeq$ 7000 EUR) on my project *$B_{(s)}$ and $D_{(s)}$ mesons inclusive semi-leptonic decays from Lattice QCD*.

2019 – 2023 **Mayflower Scholarship for PhD Studies** — University of Southampton
Competitive fully funded PhD scholarship in the School of Physics and Astronomy.

2017 – 2018 **Scholarship for Excellent Students of Collegio Superiore** — University of Bologna
Awarded to roughly 0.1% of the students of the entire University of Bologna.

2013 – 2015 **National Scholarship for Excellent Students** — Ministry of Education, Italy
Awarded to the best high school ranking students for the year 2013 at the national level.

Publications

Full list on iNSPIRE

- *The strange and flavor-singlet axial form factors of the nucleon from lattice QCD*, **AB**, D. Djukanovic, G. von Hippel, H. B. Meyer, K. Ottnad and H. Wittig [arXiv:2605.06559 [hep-lat]]
- *Inclusive semileptonic $D_s \to X_s \ell \bar{\nu}$ decays from lattice QCD: continuum and chiral extrapolation*, R. Kellermann, **AB**, A. Elgaziari, S. Hashimoto, Z. Hu, A. Jüttner and T. Kaneko, [arXiv:2604.22201 [hep-lat]]
- *Inclusive semileptonic decays from lattice QCD: analysis of systematic effects*, R. Kellermann, **AB**, A. Elgaziari, S. Hashimoto, Z. Hu, A. Jüttner and T. Kaneko, Phys. Rev. D 112, 014501 [arXiv:2504.03358 [hep-lat]].
- *The isoscalar octet axial form factor of the nucleon from lattice QCD*, **AB**, D. Djukanovic, G. von Hippel, J. Koponen, H. B. Meyer, K. Ottnad and H. Wittig, Phys. Rev. D 112, 014503 [arXiv:2503.18848 [hep-lat]].
- *Approaches to inclusive semileptonic $B_{(s)}$-meson decays from Lattice QCD*, **AB**, S. Hashimoto, A. Jüttner, T. Kaneko and R. Kellermann, JHEP 07 (2023) 145 [arXiv:2305.14092 [hep-lat]].
- *aportelli/Hadrons: Hadrons v1.3*, A. Portelli, R. Abott, N. Asmussen, **AB**, P.A. Boyle, F. Erben et al., Zenodo (2022), [zenodo.6382460].

Talks, Seminars and Workshop Organisation

17/02/2026 **The semileptonic B frontier** — Frascati, Italy
Invited speaker, *Inclusive B_s decays from lattice QCD*.

06/11/2025 **Lattice 2025** — Mumbai, India
Speaker, *Flavor structure of the nucleon axial form factor from lattice QCD*.

18/09/2025 **CKM Workshop** — Cagliari, Italy
Invited speaker, *$B_s \to D_s^{**}$ using lattice QCD*.

03/10/2024 **Lattice meets continuum** — Siegen, Germany
Invited speaker, *Inclusive semileptonic decays on the lattice*.

29/07/2024 **Lattice 2024** — Liverpool, UK
Speaker, *The isoscalar non-singlet axial form factor of the nucleon from lattice QCD*.

11/07/2024 **Lattice@CERN 2024** — CERN, Switzerland
Invited speaker, *Towards inclusive semileptonic decays from lattice QCD*.

18/06/2024 **Progress in Algorithms and Numerical Tools for QCD** — Orsay, France
Invited speaker, *Chebyshev and Backus-Gilbert reconstruction for inclusive semileptonic $B_{(s)}$-meson decays from Lattice QCD*.

31/07/2023 **Lattice 2023** — Fermilab, USA
Speaker, *Chebyshev and Backus-Gilbert reconstruction for inclusive semileptonic $B_{(s)}$-meson decays from Lattice QCD*.

23/01/2023 **HU Berlin / NIC DESY Zeuthen Joint Lattice Seminar (virtual)** — DESY, Germany
Invited speaker, *Inclusive semi-leptonic $B_{(s)}$ mesons decay at the physical b quark mass*.

6-7/09/2022 **From Particle Physics to Gravitation: the Crossover with Data Science** — Southampton, UK

Leading organiser. I successfully applied for funding (£5,000) to organise one of the SEPnet student-led conferences. The conference addressed the necessity of Data Science and High Performance Computers in Theoretical Physics, and covered topics from particle physics — such as phenomenology and lattice QCD — to gravitation and cosmology, with a particular focus on the application of techniques from fields like artificial intelligence, ML and data generation.

12/08/2022 **Lattice 2022** Bonn, Germany
Speaker, *Inclusive semi-leptonic $B_{(s)}$ mesons decay at the physical b quark mass*.

21/06/2022 **TH Informal Lattice Meeting (virtual)** CERN, Switzerland
Invited speaker, *Inclusive semi-leptonic $B_{(s)}$ mesons decay from Lattice QCD*.

17/06/2022 **Quirks in Flavour Physics** Zadar, Croatia
Speaker, *Inclusive semi-leptonic $B_{(s)}$ mesons decay from Lattice QCD*.

13/12/2021 **BNL-HET & RBRC Joint Workshop "DWF@25" (virtual)** BNL, USA
Invited speaker, *A variance reduction technique for hadronic correlators with partially twisted boundary conditions*.

29/06/2021 **Lattice 2021 (virtual)** MIT, USA
Speaker, *A variance reduction technique for hadronic correlators with partially twisted boundary conditions*.

Additional Training

09/2022 **LatticeNET School on Computing in HEP** Benasque Center for Physics
GPU programming, parallel algorithms, quantum computing, ML applications in scientific computing.

08/2021 **EuroPLex Summer School 2021 (virtual)** University of Edinburgh
Particle physics phenomenology, lattice field theory, algorithms, HPC practices.

07/2021 **Methods of Effective Field Theory and Lattice Field Theory** Bad Honnef Physics School
Effective field theory methods and their interplay with lattice field theory.

03/2021 **EXALAT School — binaries (virtual)** EXALAT
x86 architecture, executable binaries, debugging, profiling, and reverse engineering.

02/2021 **EXALAT School — GPU coding (virtual)** EXALAT
CUDA programming, GPU architectures, memory optimization, and multi-GPU processing.

01/2021 **BUSSTEP 50 (virtual)** Queen Mary University of London
Advanced QFT, amplitudes, CFT, cosmology, lattice field theory, and phenomenology.

03/2020 **PREFIT School** DESY
Precision EFT calculations, experimental techniques, data fitting, ML for LHC physics.

Supervising and Mentoring Activities

10/2023 – now **Co-supervisor for a PhD student** University of Southampton
Co-supervision of a student working on a project addressing systematic effects in inclusive semileptonic $B_{(s)}$-meson decays. Close mentoring in weekly meetings, including theoretical foundations of the physical process and analysis of large datasets.

Teaching

2019 – 2023 **Teaching Assistant and Demonstrator** University of Southampton
Teaching assistant (Statistical Mechanics, Nuclei and Particles): led problem classes, coordinated teams of 3-6 demonstrators, and contributed to final assessment. Demonstrator in undergraduate courses (Classical Mechanics, Electricity and Magnetism, Electromagnetism).