

Davide Fazzini

Curriculum Vitae

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Education

- 2015-2018 **PhD, Università degli Studi di Milano Bicocca, Italy,**
Title: *Measurements of CP violation in B decays to charmless charged two-body final states at LHCb,*
Supervisors: *Prof. Marta Calvi, Co-supervisor: Stefano Perazzini*
- 2012-2014 **Master, Università degli Studi di Milano Bicocca, Italy,**
Title: *Development of "same side" flavour tagging algorithms for measurements of flavour oscillations and CP violation in the B^0 mesons system,*
Supervisors: *Prof. Marta Calvi & Dr. Bassem Khanji*
- 2009-2012 **Bachelor, Università degli Studi di Milano Bicocca, Italy,**
Title: *Calibrazione, linearità e risoluzione della misura dell'energia dei fotoni in CMS,*
Supervisor: *Prof. Tommaso Tabarelli de Fatis*

Awards & Fellowships

- Nov 2023-Dec 2024 **Bicocca Starting Grant 2023, Machine learning of the statistics of atmospheric extremes in mountain regions,** Milano, Italy
- Jun 2018 **1st Prize for poster at LHCP 2018,** Bologna, Italy
- Jan 2018-Dec 2018 **INFN fellowship, Cooperation Associate (COAS) program.,** CERN, INFN

Current and past projects

- Jun 2024-May 2027 **RTDA, LHCb group,** Università degli studi di Milano-Bicocca & INFN, Milano, Italy
- Jun 2020-May 2024 **PostPhD, LHCb group,** Università degli studi di Milano-Bicocca & INFN, Milano, Italy
- Mar 2019-May 2020 **PostPhD, LHCb group,** Centre National de la Recherche Scientifique (CNRS) & LAL, Orsay, France
- Nov 2015-Feb 2019 **PhD student, LHCb group,** Università degli studi di Milano-Bicocca, Milano, Italy
- May 2015-Aug 2015 **CERN User, CERN, LHCb group,** Rio de Janeiro, Brazil
- Mar 2014-Mar 2015 **Master student, LHCb group,** Università degli studi di Milano-Bicocca, Milano, Italy
- Jul 2012-Oct 2012 **Bachelor student, CMS group,** Università degli studi di Milano-Bicocca, Milano, Italy

Scientific responsibilities

- Mar 2024-ongoing **SL Sub-Convener, convenership of the "Exclusive semileptonic decays" sub-working group for the LHCb experiment**
- Mar 2023-ongoing **DaVinci release manager, responsible for the correct release and deployment of the offline analysis software stack within the LHCb collaboration**
- Jun 2022-ongoing **Internal physics referee, for the paper "Measurement of the branching fraction ratio and Δa_{CP} of the decays $B^- \rightarrow J/\psi\pi^-$ and $B^- \rightarrow J/\psi K^-$ ",** paper in preparation

Oct 2020-Sep 2021 **Internal physics referee**, for the paper "Precise determination of the $B_s^0 - \bar{B}_s^0$ oscillation frequency", "Nat. Phys. 18, 1-5 (2022), DOI: 10.1038/s41567-021-01394-x

Nov 2015-May 2024 **LHCb Liaison**, ensuring the exchange of information between the simulation and the flavour tagging working group

Scientific interests

Physics beyond the Standard Model **Search for lepton flavour violating τ decays, measurement of D^* polarisation, measurement of the V_{ub} element of the CKM matrix**

CP violation **Measurement of CPV in charmless B^0 decays, development of tagging algorithms for identifying the B^0 flavour**

Simulation & computing **Modernization of the codes increasing their flexibility, implementation of new features improving the user experience**

New features for Future LHCb detector **Improvement in RICH PID performance when introducing time information**

Contributions to International and National Conferences

- April 2024 **Status and prospects of $B_s^0 \rightarrow K\mu\nu_\mu$ analysis at LHCb**, *Talk*, 5th Beyond the Flavour Anomalies Workshop, 2024, Siegen, Germany
- Nov 2023 **Overview of time-integrated CP violation in beauty-hadron decays**, *Talk*, Workshop Italiano sulla Fisica ad Alta Intensità, WIFAI 2023, Roma, Italy
- Jul 2023 **Recent results in semileptonic B decays at LHCb**, *Talk*, 21st International Conference on B -Physics at Frontier Machines, BEAUTY 2023, Clermont-Ferrand, France
- Jul 2022 **Offline data processing and analysis at LHCb in the 2020s**, *Talk*, 41st International Conference on High Energy Physics, ICHEP 2022, Bologna, Italy
- Sep 2021 **Misura della polarizzazione longitudinale del mesone D^* in decadimenti di $B^0 \rightarrow D^* \tau \nu_\tau$ a LHCb**, *Talk*, 107^o Congresso SIF, Virtual
- Jul 2021 **CP violation in the beauty sector at LHCb**, *Talk*, LISHEP 2021 - Session C, Rio de Janeiro, Brazil
- Jul 2020 **Measurement of CP violation in charmless 2-body B meson decays at LHCb**, *Talk*, 40th International Conference on High Energy Physics, ICHEP 2020, Prague, Czech Republic
- Sep 2018 **Time dependent CPV in $B_{(s)}^0 \rightarrow hh$ decays at LHCb**, *Talk*, 10th CKM Workshop, Heidelberg, Germany
- Jun 2018 **Time-dependent CP violation in $B_{(s)}^0 \rightarrow hh$ & Flavour-tagging in the LHCb experiment**, *Poster & Talk*, 6th LHCP, Bologna, Italy
- Apr 2018 **Misura della violazione di CP in decadimenti dei mesoni B in due corpi carichi senza charm a LHCb**, *Talk*, IFAE 2018, Milano, Italy
- Feb 2018 **Time-dependent CP violation in $B_s^0 \rightarrow hh$ decays**, *Poster*, 133rd LHCC meeting, CERN Geneve, Switzerland
- Mar 2016 **New algorithms for Flavour Tagging at the LHCb experiment**, *Poster*, 125th LHCC Meeting, CERN Geneve, Switzerland

- Sep 2016 **Misure di violazione di CP nei decadimenti a due corpi carichi senza charm a LHCb**, *Talk*, 102° Congresso SIF, Padova, Italy
- Mar 2016 **Nuovi algoritmi di Flavour Tagging all'esperimento LHCb**, *Talk*, IFAE 2016, Genova, Italy

Teaching experience

- Oct 2023–Sep 2024 **Tutor**, *Laboratory I of Physics*, Bachelor degree, (annual)
- Oct 2022–Jul 2023 **Co-Tutor master thesis**, titled "*Study on the $B_s^0 \rightarrow K^+ \mu^- \nu_\mu$ decay for the measurement of the matrix element $|V_{ub}|$* "
- Oct 2022–Sep 2023 **Contract professor**, *Laboratory I of Physics*, Bachelor degree, (annual)
- Feb 2022 **Co-Tutor bachelor thesis**, titled "*Applicazioni di Machine Learning alla ricerca della violazione della conservazione del sapore leptonic nel decadimento $\tau^- \rightarrow \mu^- \mu^+ \mu^-$* "
- Oct 2021–Sep 2022 **Tutor**, *Laboratory I of Physics*, Bachelor degree, (annual)
- Mar 2021–Sep 2021 **Tutor**, *Laboratory I of Physics*, Bachelor degree, (1 semester)
- Mar 2017–Sep 2017 **Contract professor**, *Laboratory I of Physics*, Bachelor degree, (1 semester)
- Mar 2016–Sep 2016 **Contract professor**, *Laboratory I of Physics*, Bachelor degree, (1 semester)

Attended PhD Schools

- 06-19 Sep 2017 **The European Schools of High-Energy Physics 2017**, *Evora, Portugal*
- 07-11 May 2017 **INFN School of Statistics 2017**, *Ischia, Italy*
- 20-24 Jun 2016 **2nd School on Scientific Data Analytic and Visualization**, *Bologna, Italy*

Outreach activity

- 2022-23 **LHCb Masterclass**, *Milano, Italy*, Università di Milano-Bicocca
- 2021-22 **LHCb Masterclass**, *Milano, Italy*, Università di Milano-Bicocca
- 2022 **LHCb Starterkit**, *CERN Switzerland*

Programming & computer skills

- Operating System **Linux, Windows, Mac**, *professional*
- Programming **C/C++/C#, python, perl, bash**, *professional*
- Typesetting **LaTeX, Microsoft Word, OpenOffice**, *professional*
- Framework **ROOT, RooFit, TMVA**, *professional*
- Editor **Visual Studio, Kile, Emacs, Vim**, *professional*
- Engine **Unity**, *beginner*
- Graphics **Gimp, Blender**, *beginner*

Languages

- Italian **Native**
- English **B2**

Other interests

Computer science, Geopolitics, Chess, Volleyball, Reading, Music

Research experience

Jun 2024–May 2027 **RTDA Università degli studi di Milano-Bicocca, Milano, Italy**

”Study and Simulation of Advanced Scintillating Calorimeters’

The project aims to develop advanced detectors for future particle colliders by focusing on the study and simulation of scintillating calorimeters:

- Aim: achieve detectors with high spatial and temporal resolution, capable of operating at high data rates and withstanding high radiation environments.
- Identifying and characterizing suitable inorganic scintillating crystals.
- Designing and constructing high-performance prototypes.
- Utilizing advanced AI techniques to create accurate simulation models.

"Measurement of the V_{ub} CKM matrix element using $B_s^0 \rightarrow K^- \mu^+ \nu_{mu}$ decay at LHCb"

My work is focused on the determination of the V_{ub} element of the CKM matrix exploiting the $B_s^0 \rightarrow K^- \mu^+ \nu_{mu}$ decay channel.

- Aim: determine the V_{ub} and the form factor values of the $B_s^0 \rightarrow K^- \mu^+ \nu_{mu}$ decay mode
- Analysis uses full Run 2 sata sample, corresponding to 5.9 fb^{-1}
- Implemented the base structure of the new analysis framework for creating, processing and fitting the data samples. Framework validated through a detailed study on a set of pseudo-experiments.
- Currently working on to determination of the sensitivity to the $B_s^0 \rightarrow K^- \mu^+ \nu_{mu}$ form factor.
- Next steps will involve the implementation of tools for rejecting background with K^* resonances.

"Search for the lepton flavour violating decay $\tau^- \rightarrow \mu^- \mu^+ \mu^-$ at LHCb"

Part of my work has been focused on the research of the rare decay $\tau^- \rightarrow \mu^- \mu^+ \mu^-$.

- Aim: measure an upper limit to the $\tau^- \rightarrow \mu^- \mu^+ \mu^-$ branching ratio (BR) with $D_s^- \rightarrow \phi(\mu^+ \mu^-) \pi^-$ as reference channel
- Analysis uses Run 2 data sample, corresponding to 5.9 fb^{-1}
- Performed a detailed study on the correction for data/MC difference in particle identification (PID) variables used in the analysis to select the signal.
- Performed a study on the contamination of charm physics backgrounds in the signal region due to mis-identification of muons as kaons or pions. Dominant contribution come from $D^+ \rightarrow K \pi \pi$ and $D_{(s)}^+ \rightarrow \pi \pi \pi$ channels.
- Analysis is in an advance status and will enter in working group review soon

"Improved Particle Identification in RICH introducing timing at LHCb"

During the first year I also performed some studies on the effect of timing in RICH performance on simulated sample in Upgrade conditions:

- Aim: evaluating the improvement in background rejection when introducing the fast timing information in the PID variable determination
- Time information is determined using a time-gate around the expected RICH detector hit time
- Study is performed on simulated sample of $B \rightarrow hh'$ decay modes in Upgrade II conditions
- Comparison of PID performances obtained with three different time-configurations.
- Results are reported in the "LHCb RICH: Potential physics performance" public note ([LHCb-PUB-2021-009](#)), published along with the LHCb FTDR for Upgrade II ([LHCb-TDR-023](#))

"Restructuring and modernizing LHCb offline code"

I am also involved in revisiting and rewriting part of the official LHCb offline analysis software needed for the Run3.

- Developed a completely new DaVinci environment based on the new GaudiConfig2 framework
- I was responsible for the configuration part, making it more powerful and flexible
- The new software is now complete and the documentation can be found on the [lhcb-dpa website](#)
- Currently working on the DaVinci maintenance and features enhancement
- I am also responsible for the "LHCbIntegrationTests" package aimed to test the correct workflow of the full LHCb chain up to the production of the final tuples for the users.

Other activities

- I finalized the D^* polarization measurement, [arXiv:2311.05224](#) now submitted to PRD.
- I am covering the liaison position between the Flavour Tagging and Simulation working group.
- Since March 2023 I took the role of DaVinci release manager, responsible for the correct release and deployment of the offline analysis software stack within the LHCb collaboration.
- I won the "Bicocca Starting Grant" with a multidisciplinary project with DISAT Bicocca: "Machine learning of the statistics of Atmospheric eXtremes in Mountain regions". The aim is to develop a machine learning algorithm for predicting the statistical properties of small-scale atmospheric fields in mountain regions. The work will be carried out during the 2024.

Mar 2019–May 2020 **PostPhD at CNRS & LAL, Orsay, France,**

“Measurement of D^* polarisation and New Physics effects in $B^0 \rightarrow D^* \tau \nu$ decays”

My work was focused on an angular analysis regarding on the $B^0 \rightarrow D^{*-} \tau^+ \nu_\tau$:

- Aim: measuring the longitudinal D^* polarisation fraction and the New Physics (NP) effects on $B^0 \rightarrow D^{*-} \tau^+ \nu_\tau$ ($\tau \rightarrow \pi^+ \pi^- \pi^+ \nu_\tau$) decays
- Only Belle measured the D^* polarisation fraction so far, first measurement of D^* polarisation at hadronic collider.
- Very important to provide an independent result improving the overall precision
- Analysis performed using the data collected during the Run 1 and the first part of Run 2 ($3 \text{ fb}^{-1} + 2 \text{ fb}^{-1}$)
- A dedicated fitter based on a 4D binned template was implemented, exploiting Hammer tool to take into account the effect of NP processes due to tensor lepto-quark
- D^* polarisation fraction was determined directly from the projection of the signal helicity angle
- Analysis published in 2023 [arXiv:2311.05224](https://arxiv.org/abs/2311.05224)

During this period I was still covering my position as liaison between the Flavour Tagging and Simulation working group.

Nov 2015–Oct 2018 **PhD at Università degli Studi di Milano Bicocca, Italy,**

“Measurements of time-integrated and time-dependent CP violation in charmless charged two-body B decays at LHCb”

My PhD thesis focuses on CP violation in $B_{(s)}^0 \rightarrow hh'$ ($h, h' = K, \pi$) decays at LHCb:

- Aim: measurement of the CKM angles α , γ , β and β_s
- I joined the previous analysis based on Run 1 data (3 fb^{-1}), published ([Phys-Rev-D98](#))
- In the following analysis update, we included data collected during Run2 ($\sim 2.0 \text{ fb}^{-1}$)
- Developed a fitting algorithm to extract the CP asymmetries, in the decay and in the interference between mixing and decay, in $B_{(s)}^0 \rightarrow h^+ h^-$ decays.
- Developed an algorithm to efficiently select signal candidates based on multivariate analysis.
- Studied the calibration of the tagging algorithms, used to determine the signal B flavour at production: key information in the measurement of the time-dependent CP observables.
- Studied the decay-time resolution, a fundamental ingredient for the measurement of the CP asymmetries of the B_s^0 meson, because of its very fast oscillation frequency.
- Determination of the final correction to the time-integrated raw asymmetries, due to the differences between the reconstruction and particle identification efficiencies.
- This analysis represent the first observation of time-dependent CPV in B_s^0 sector, results have been published ([JHEP-03-075](#)) and presented at an international conference.

I took the role of liaison between the Flavour Tagging and Simulation working group.

May 2015–Aug 2015 **Centro Brasileiro de Pesquisas Fisicas, Brazil,**

“Implementation of generator statistics in File Summary Record for the LHCb simulation”

- Aim: Store the generator statistics for generator efficiency evaluation in Gaudi File Summary Record (FSR)
- A dedicated implementation of the generator counters in FSR format and of the merging for the generator FSR was provided
- The project has been carried out at CERN in collaboration with expert from the LHCb Simulation and Core Computing teams and a detailed documentation was prepared as LHCb Internal Note

- Mar 2014–Mar 2015 **Master at Università degli Studi di Milano Bicocca, Italy,**
”Development of same side flavour tagging algorithms for measurements of flavour oscillations and CP violation in the B^0 mesons system”
- Aim: development of Same Side Tagger algorithms
 - Re-tuned the tagging algorithms using the protons and pions to infer the signal B^0 initial flavour
 - Calibrated the tagging algorithms in $B_d \rightarrow D^- \pi^+$ decays and $B_d \rightarrow K^+ \pi^-$ decays
 - Increased the tagging power of SS pion tagger by 60% with respect to the previous tagger
 - Provide two same side taggers along with their combination that are currently used in many time-dependent CP violation analysis in the LHCb collaboration
 - Final results have been published in [Eur-Phys-J-C77](#)
- Jul 2012–Oct 2012 **Bachelor at Università degli Studi di Milano Bicocca, Italy,**
”Calibrazione, linearità e risoluzione della misura dell’energia dei fotoni in CMS”
- Aim: Calibrate the energy measurement of the photons in CMS calorimeter
 - Used a regression method to derive the cluster energy corrections from data using a constraint of the mass of Z
 - The $Z \rightarrow ee$ candidates have been selected
 - The final results showed an improvement in the Z mass resolution

List of publications

Public papers, as principal author

1. The LHCb Collaboration, R. Aaij et al, "Measurement of the longitudinal D^* polarization in $B^0 \rightarrow D^* \tau \nu_\tau$ decays with hadronic τ^+ channel at LHCb", published on arXiv:2311.05224 (2023), submitted to PRD
2. M. Calvi, et al., "LHCb RICH: Potential physics performance", LHCb-PUB-2021-009
3. The LHCb Collaboration, R. Aaij et al, "Observation of CP violation in two-body $B_{(s)}^0$ -meson decays to charged pions and kaons", JHEP 03 (2021) 075 (2021), DOI: 10.1007/JHEP03(2021)075
4. The LHCb Collaboration, R. Aaij et al, "Measurement of CP asymmetries in two-body $B_{(s)}^0$ -meson decays to charged pions and kaons", Phys. Rev. D 98 (2018), DOI: 10.1103/PhysRevD.98.032004
5. The LHCb Collaboration, R. Aaij et al, "New algorithms for identifying the flavour of B^0 mesons using pions and protons", Eur. Phys. J. C 77 (2017), DOI: 10.1140/epjc/s10052-017-4731-y

Public papers, as a member of LHCb

1. Full list of the publications: 421 papers (in attachment) , h index = 58 <https://www.scopus.com>

LHCb internal & analysis notes

1. F. Archilli et al, "Search for the $\tau^+ \rightarrow \mu^+ \mu^- \mu^+$ decay", LHCb-ANA-202Y-XXX (in preparation)
2. D. Fazzini et al, " D^* polarisation measurement in $B^0 \rightarrow D^* \tau \nu$ decays", LHCb-ANA-2020-26
3. M. T. Alexander et al, "Measurement of CP asymmetries in two-body $B_{(s)}^0$ -meson decays to charged pions and kaons", LHCb-ANA-2018-025, (2020)
4. M. Calvi et al, "Studies on the $SS\Lambda$ tagger", LHCb-ANA-2018-031, (2018)
5. S. Perazzini et al, "Measurement of time-dependent CP -violating asymmetries in $B^0 \rightarrow \pi^+ \pi^-$ and $B_s^0 \rightarrow K^+ K^-$ decays at LHCb", LHCb-ANA-2017-003, (2017)
6. G. Corti et D. Fazzini, "Implementation of generator statistics in File Summary Record for the LHCb simulation", LHCb-INT-2015 (2015)
7. M. Calvi et al, "New algorithms to tag the flavour of B^0 mesons using pions and protons, LHCb-ANA-2015-061, (2015)

Theses

1. D.Fazzini, "Measurements of time-integrated and time-dependent CP violation in charmless charged two-body B decays at LHCb", CERN-THESIS-2019-328 - Milano: Milano Bicocca, 2019. - 249 p.
2. D. Fazzini, "Development of same side flavour tagging algorithms for measurements of flavour oscillations and CP violation in the B^0 mesons system", CERN-THESIS-2015-040 - Milano : Milano-Bicocca, 2015. - 142 p.
3. D.Fazzini, "Calibrazione, linearità e risoluzione della misura dell'energia dei fotoni in CMS", Milano : Milano-Bicocca, 2012. - 41 p.

Proceedings, Talks & Posters

1. Talk, "Overview of time-integrated CP violation in beauty-hadron decays", 2^o Workshop Italiano sulla Fisica ad Alta Intensità (2023), Roma (Italy)
2. Talk, "Recent results in semileptonic B decays at LHCb", 21st International Conference on B -Physics at Frontier Machines (2023), Clermont-Ferrand (France)
3. Talk, "Offline data processing and analysis at LHCb in the 2020s", 41st International Conference on High Energy Physics (2022), Bologna (Italy), PoS ICHEP2022 (2023), DOI: 10.22323/1.414.0230
4. Talk, "Misura della polarizzazione longitudinale del mesone D^* in decadimenti di $B^0 \rightarrow D^* \tau \nu_\tau$ a LHCb", 107^o Congresso Nazionale della SIF (2021), Virtual
5. Talk, " CP violation in the beauty sector at LHCb", LISHEP 2021 - Session C, Rio de Janeiro (Brazil)
6. Talk, "Measurement of CP violation in charmless 2-body B meson decays at LHCb", 40th International Conference on High Energy Physics, Prague (Czech Republic), PoS ICHEP2020 (2021), DOI: 10.22323/1.390.0372
7. Talk, "Time dependent CPV in $B_{(s)}^0 \rightarrow hh$ decays at LHCb", 10th International Workshop on the CKM Unitarity Triangle (2018), Heidelberg (Germany)
8. Talk, "Flavour-tagging in the LHCb experiment", 6th Annual Conference on Large Hadron Collider Physics 2018, Bologna (Italy), PoS LHCP2018 (2018), DOI: 10.22323/1.321.0230
9. Poster, "Time-dependent CP violation in $B_{(s)}^0 \rightarrow hh$ ", 6th Annual Conference on Large Hadron Collider Physics 2018, Bologna (Italy), PoS LHCP2018 (2018) DOI: 10.22323/1.321.0063
10. Poster, "Time-dependent CP violation in $B_{(s)}^0 \rightarrow hh$ decays", 133rd LHCC meeting 2018, CERN (Geneva, Switzerland)
11. Talk, "Misura della violazione di CP in decadimenti dei mesoni B in due corpi carichi senza charm a $LHCb$ ", IFAE 2018 - Incontri di Fisica delle Alte Energie, Milano (Italy), NCC Vol. 42 Issue 4 (2019), DOI: 10.1393/ncc/i2019-19147-1
12. Poster, "New algorithms for Flavour Tagging at the $LHCb$ experiment", 125th LHCC meeting 2016, CERN (Geneva, Switzerland)
13. Talk, "Nuovi algoritmi di Flavour Tagging all'esperimento LHCb", IFAE 2016 - Incontri di Fisica delle Alte Energie, Genova (Italy), NCC Vol. 40 Issue 1 (2017), DOI: 10.1393/ncc/i2017-17046-1
14. Talk, "Misure di Violazione di CP nei decadimenti a due corpi carichi senza charm a $LHCb$ ", 102^o Congresso Nazionale della SIF (2016), Padova (Italy)