Vinicius Mikuni

Education

2017 – 2021 **PhD in physics**, *University of Zurich*.

2015 – 2017 **Master in physics**, *University of São Paulo*.

2013 **Internship**, *University of Glasgow*.

2011 – 2015 **Bachelor in Physics**, *University of São Paulo*.

PhD Thesis

Institute University of Zurich, Switzerland.

Title **Collider Physics Measurements in High Jet Multiplicity Final States**.

Supervisor Prof. Florencia Canelli.

Description Performed the first search for vector-like leptons to third generation fermion final states and the first measurement of the top quark pair production cross section with additional b jets in the all hadronic final state. State-of-the-art results were achieved by novel usage of machine learning methods in collider physics, enabling precision and sensitivity beyond traditional approaches. Machine learning techniques were developed and used to improve the signal sensitivity. Developed the ABCNet algorithm, the first transformer based model used in Collider Physics, applied to the separation of quark-gluon jets. In addition, UCluster, an anomaly detection algorithm, and PCT, a graph neural network combined with a transformer architecture, were developed in the context of jet flavor tagging and searches for new physics interactions. Organized the first University of Zurich interdisciplinary ML workshop.

Master thesis

Institute University of São Paulo, Brazil and CERN, Switzerland.

Title **Measurement of cosmic ray electrons and positrons with the AMS-02 experiment**.

Supervisor Prof. Manuela Vecchi.

Description Performed the first measurement of the time-dependent flux of cosmic ray electrons and positrons using the data collected by the AMS-02 experiment during the first 5 years of operations. Focused specifically on low-energy cosmic rays to provide insights into the influence of solar activity on the cosmic ray spectrum and the temporal evolution of solar modulation during data-taking, significantly improving the understanding of electron and positron cosmic ray fluxes.

Work Experience

2025 – **Associate Professor**, *KMI Institute, Nagoya University*.

2021 – 2025 **NESAP Postdoctoral Fellow**, *Lawrence Berkeley National Laboratory*.

Research **New Methodologies to Improve Precision and Accelerate Discovery in Physical Sciences**.

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Developed and applied new methodologies incorporating deep learning into collider physics applications, overcoming the limitations from traditional approaches and improving upon state-of-the-art methods.

- **Fast Detector Simulation**: Developed several algorithms to accelerate standard physics simulation routines, achieving calorimeter and telescope imaging simulation routines hundreds to thousands of times faster than traditional algorithms. Developed algorithms include the first application of diffusion generative models for calorimeters. Resulting projects were documented in five publications in peer review journals.
- **Anomaly Detection of New Physics Phenomena**: Led the development of different strategies to identify new physics processes through the identification of deviations from current theory predictions within a high-dimensional setting. These efforts led to four published papers in peer reviewed journals with one paper selected for the Editors' Suggestion in the Physical Review D journal.
- **Detector Unfolding**: Developed and improved methods for high dimensional and unbinned unfolding. Applied the improvements to experimental data using electron-proton scattering to achieve high precision and resulting in one of the first science results with the Perlmutter supercomputer. These advancements have been documented in three published works in peer reviewed journals.

Event Organization and Tutorials

2024 **Berkeley AI4Science Summit**.
Organizer of the Berkeley AI4Science Summit Workshop, responsible for selecting speakers and organizing the logistics of the event.

2023, 2024 **NeurIPS**.
Organizer of the Machine Learning and the Physical Sciences Workshop, responsible for organizing the logistics of the event and appointed Guess Editor of an upcoming focus collection publication covering results presented in the workshop.

2023 **AI4EIC**, Catholic University of America, United Stated of America.
Convener of the AI/ML for Data Analysis and Theory, responsible for inviting the speakers, moderating the session, and reporting the activities performed during the workshop.

2023 **BOOST23**, Lawrence Berkeley National Laboratory, United Stated of America.
Part of the local event organizing committee, responsible for moderating the Tagger Resilience session.

2023 **PhysTeV 2023**, Les Houches, France.
Machine learning convener of the Standard Model session, responsible for inviting relevant participants, documenting the activities, and organizing the talks during the event.

2022 **AI4EIC**, William and Mary, Raymond A. Mason School of Business, Alan B. Miller Hall, United Stated of America.
Tutorial given on machine learning-based unfolding for the Electron-Ion Collider.

2022 **Snowmass 2021**.
Organized the Snowmass contribution on fast detector simulation and differentiable programming for collider physics, responsible for inviting participants and editing the document submitted for the Snowmass community study.

2022, 2023 **ATLAS ML training program**, Lawrence Berkeley National Laboratory, United Stated of America.
Tutorial given on anomaly detection for new physics searches using the CORI and perlmutter Supercomputers.

2021 **UZH Machine learning workshop**, University of Zurich, Switzerland.
Main organizer of the first interdisciplinary machine learning workshop at the the university of Zurich, responsible for secure funding, selecting speakers, and moderating the talks.

2021 - 2023 **Machine Learning and Science Forum**, Berkeley Institute for Data Science, United Stated of America.
Co-organizer of the Machine Learning and Science Forum responsible for the invitation of speakers, organization, and moderation of seminars.

Referee Activities

- Journal of High Energy Physics
- Computing and Software for Big Science
- Physical Review journals and Reviews of Modern Physics
- European Physical Journal
- Frontiers in Big Data: Big Data and AI in High Energy Physics
- SciPost Physics
- Machine Learning: Science and Technology
- NeurIPS Workshop: Machine Learning and the Physical Sciences

Professionalization courses

2016 **Pedagogical Practices in Higher Education**, University of Sao Paulo, Attended the semester long course on modern pedagogical practices in Higher Education. Achieved the grade of A, the highest grade offered in the course.
60 hours in total.

Teaching Experience

2019-2020 **Teaching assistant of Physics II**, *20 hrs/wk*, University of Zurich.

2019-2020 **Teaching assistant of Physics I**, *20 hrs/wk*, University of Zurich.

2018 **Teaching assistant of Physics I Lab for physicists**, *10 hrs/wk*, University of Zurich.

2017 **Teaching assistant of Physics I Lab for physicists**, *5 hrs/wk*, University of Zurich.

2016 **Teaching assistant of Physics I**, *10 hrs/wk*, University of São Paulo.

2015 **Teaching assistant of Modern Physics II**, *5 hrs/wk*, University of São Paulo.

Student Supervision at Undergraduate, Postbaccalaureate, or Masters Level

2024 - **Alina Sheng**, *Postbaccalaureate*, University of California Berkeley.
Fine-tuning astronomical models using collider data.

2024 - **Pradyun Hebbar**, *Postbaccalaureate*, IISER.
Comparison of pretraining tasks for Foundational Models in Collider Physics.

2024 - **Nishank Gite**, *Undergraduate student*, University of California Berkeley.
Upper limit to classification performance in jet tagging.

2023 - 2024 **Yash Melkani**, *Undergraduate student*, University of California Berkeley.
Faster diffusion generative models for jet generation.

2022 **Jason Wong**, *Undergraduate student*, University of California Berkeley.
Score-based generative models using graph neural networks for collider physics.

2022 **Chirag Furia**, *Undergraduate student*, Rutgers University.
Calorimeter detector simulation with continuous normalizing flows.

2022 **Alp Altug**, *Undergraduate student*, University of California Berkeley.
Resonant anomaly detection with continuous normalizing flows.

2021 **Vikas Ummadisetty**, *Undergraduate student*, University of California Berkeley.
Domain adaptation strategies for collider physics.

2021 **Eduardo Ploerer**, *Master student*, University of Zurich.
Jet flavor tagging using graph neural networks.

Student Supervision at PhD Level

2024 - **Lark Wang**, *Graduate student*, University of California Berkeley.
Fast surrogate models for telescope image generation.

2023 **Jack Harrison**, *Graduate student*, IFAE.
Density estimation with diffusion generative models respecting the Fokker-Plank equation.

2023 - **Nathan Suri**, *Graduate student*, Yale University.
Pileup mitigation at the LHC using optimal transport.

2023 - **Thandi madula**, *Graduate student*, University College London.
Diffusion generative models in latent space for calorimeter simulation and encouraged symmetries for HEP models.

2022 **Haoxing Du**, *Graduate student*, University of California Berkeley.
Maximum likelihood inference with neural density estimation.

Presentations at International Conferences

2024 **RPM Talks LBL**, *Colloquium*, Berkeley, USA, Click here to access the website.
OmniLearn: Facilitating All Jet Physics Tasks

2024 **Georgia Southern University**, *Colloquium*, Georgia, USA.
Accelerating Discovery in High Energy Physics using AI

2024 **PHYSTAT**, *Invited Talk*, London, UK, Click here to access the website.
Extending Unfolding Methods With Machine Learning

2024 **BOOST 2024**, Genova, Italy, Click here to access the website.
OmniLearn: A Method to Simultaneously Facilitate All Jet Physics Tasks

2024 **ICHEP 2024**, Prague, Czech Republic, Click here to access the website.
Multi-differential Jet Substructure Measurement in High Q2 ep collisions with HERA-II Data

2024 **LHCP 2024**, *Invited Talk*, Boston, USA, Click here to access the website.
Anomaly Detection: State-of-the-Art

2024 **QCD at the Femtoscale in the Era of Big Data**, *Invited Talk*, Washington, USA, Click here to access the website.
Diffusion Generative Models for Nuclear Physics Applications.

2024 **Aspen Summer Workshop**, Aspen, USA, Click here to access the website.
Foundational Models for Science.

2024 **GTC 2024**, *Invited Talk*, California, USA, Click here to access the website.
Using Generative AI To Enable Complex Physics Discovery at CERN.

2024 **ML at HEP**, *Invited Talk*, KEK, Japan, Click here to access the website.
Review: Low-level object reconstruction and simulation using ML.

2023 **ML4Jets 2023**, Hamburg University, Germany, Click here to access the website.
High-Dimensional Diffusion Generative Models in Collider Physics.

2023 **QCD@LHC**, Durham, UK, Click here to access the website.
Jet substructure observables and azimuthal angular asymmetry in deep-inelastic scattering with H1.

2023 **EPS-HEP2023**, Hamburg, Germany, Click here to access the website.
Multi-differential Jet Substructure Measurement in High Q2 ep collisions with HERA-II Data.

2023 **Kapteyn Astronomical Institute**, *Colloquium*, Groningen, NL.
Collider Physics Innovations Powered by Machine Learning.

2023 **BOOST23**, California, USA, Click here to access the website.
Multi-differential Jet Substructure Measurement in electron-proton Collisions.

2023 **Aspen Winter Conference**, *Invited talk*, Aspen, USA, Anomaly detection.

2022 **NeurIPS 2022**, *Invited talk*, New Orleans, USA, Click here to access the website.
Collider Physics Innovations Powered by Machine Learning.

2022 **ML4Jets 2022**, Rutgers University, USA, Click here to access the website.
Score-based Generative Models for Calorimeter Shower Simulation and Multi-differential Jet Substructure Measurement in High Q^2 Deep-Inelastic Scattering with the H1 Detector.

2022 **DIS2022**, Santiago de Compostela, Spain, Click here to access the presentation.
Multi-differential Jet Substructure Measurement in High Q2 Deep-Inelastic Scattering with the H1 Detector.

2022 **Learning to Discover**, Orsay, France, Click here to access the presentation.
Online-compatible unsupervised nonresonant anomaly detection.

2020 **QCD20**, Montpellier, France, Click here to access the presentation.
Highlights on top quark measurements from CMS.

2020 **ML4jets 2020**, New York University, USA, Click here to access the presentation.
Quark-gluon discrimination with point clouds.

2019 **CMS TOP workshop**, DESY, Germany, Click here to access the presentation.
b-tagging: status, ways to improve uncertainty, expectation from UL.

2019 **3rd CMS Machine Learning Workshop**, CERN, Switzerland, Click here to access the website.
Deep neural networks for point cloud segmentation applied to low-p_T τ lepton reconstruction and Using Classification Without Labels (CWoLa) for multijet background rejection.

2019 **LHCP 2019**, BUAP, Mexico, Click here to access the presentation.
Latest CMS measurements of inclusive and differential top quark pair production.

Research Grants

2025 **SBIR/STTR Program within the Department of Energy (DOE)**, *awarded by the Department of Energy - USA*, USD 90'000.
Research grant to cooperate with small businesses for 12 months to develop new technologies relevant to the DOE program. The project title is Generative AI Training Tools for Particle Physics Simulation and aims to enable generic workflows for detector simulation in physics, astrophysics, and medical applications.

2024, 2025 **NERSC AY**, *awarded by NERSC - USA*, 20'000 GPU Hours.
Computing allocation grant to use the Perlmutter Supercomputer for scientific research.

2020 **Forschungskredit Candoc**, *awarded by University of Zurich - Switzerland*, CHF 57'546.
Research grant to PhD students from the Physik Institut of the University of Zurich to carry independent research for 12 months.

2019 **GRC Short Grant: Interdisciplinary Workshop on Machine Learning at UZH**, *awarded by University of Zurich - Switzerland*, CHF 3'226.
Graduate Campus Short Grants funds for junior researchers to organize events at the University of Zurich. Earned as a PhD student

Honors and Awards

2025 **NERSC High Performance Computing Achievement Award**, *awarded NERSC - USA*.
The NERSC HPC Achievement Awards are presented annually to recognize extraordinary contributions from early-career scientists who used NERSC in their research.

2022 **Praemierung hervorragender wissenschftlicher Arbeiten**, *awarded by University of Zurich - Switzerland*.
Ph.D. thesis award for outstanding scientific work.

2016 **Bolsa Estágio de Pesquisa no Exterior (BEPE)**, *awarded by FAPESP (São Paulo Research Foundation) - Brazil*.
Scholarship granted to masters students with excellent research achievements to carry out part of their research at any international institution for 6 months.

2015 **Masters research scholarship**, *awarded by FAPESP*.
Scholarship awarded to master students with excellent research achievements and academic records.

2015 **Masters research scholarship**, *Declined*, awarded by CNPq (National Council of Technological and Scientific Development) - Brazil.
Competitive scholarship awarded to master students. Declined in favour of the FAPESP scholarship.

2015 **Summer student program at CERN**, *awarded by CERN - Switzerland*.
Selected student from a highly competitive process between students across the world to participate in the summer program at CERN.

2014 **Research scholarship for undergraduate students**, *awarded by CNPq*.
Scholarship given in a competitive basis to undergraduate students to carry out a research project.

2013 **Science without borders**, *awarded by CNPq* .
Highly competitive scholarship sponsored by the Brazilian government covering tuition and living fees for 1 academic year to undergraduate students in any partner university around the world. The University of Glasgow was the institution chosen.

Summary of Scientific Output

- Total number of publications: 442
- Total number of publications with 10 authors or less: 27
- Total number of citations: 24,637
- Total number of citations in publications with 10 authors or less: 516
- Average FWCI (click here for the definition): 2.82
- Total h-index: 83
- h-index for publications with 10 authors or less: 11

Selected Publications

1 C. Elflein, S. Funk, J. Glombitza, V. Mikuni, B. Nachman, L. Wang, **Generation of Air Shower Images for Imaging Air Cherenkov Telescopes using Diffusion Models**, Accepted poster in the ML4PS Workshop at NeurIPS 2024

2 E. Dreyer, E. Gross, D. Kobylianskii, V. Mikuni, B. Nachman and N. Soybelman, **An Automated Approach to Accurate, Precise, and Fast Detector Simulation and Reconstruction**, Phys.Rev.Lett. 133 (2024) 21, 211902

3 H. Du, C. Krause, V. Mikuni, B. Nachman, I. Pang and D. Shih, **Unifying Simulation and Inference with Normalizing Flows**, Submitted to Phys. Rev. D

4 V. Mikuni and B. Nachman, **OmniLearn: A Method to Simultaneously Facilitate All Jet Physics Tasks**, Submitted to Phys. Rev. Lett.

5 E. Buhmann, C. Ewen, G. Kasieczka, V. Mikuni, B. Nachman, **Full phase space resonant anomaly detection**, Phys. Rev. D 109 (2024) 5, 055015.

6 A. Bal, T. Brandes, F. Iemmi, M. Klute, B. Maier, V. Mikuni and T. K. Arrestad, **Distilling particle knowledge for fast reconstruction at high-energy physics experiments**, Mach. Learn. Sci. Tech. 5, no.2, 025033 (2024).

7 S. Diefenbacher, G.-H. Liu, V. Mikuni, B. Nachman, W. Nie, **Improving generative model-based unfolding with Schrödinger bridges**, Phys. Rev. D 109 (2024) 7, 076011.

8 V. Mikuni, B. Nachman, **CaloScore v2: single-shot calorimeter shower simulation with diffusion models**, JINST 19 (2024) 02, P02001.

9 V. Mikuni, B. Nachman, **High-dimensional and Permutation Invariant Anomaly Detection**, SciPost Phys. 16 (2024) 062.

10 F. Torales Acosta, V. Mikuni, B. Nachman, M. Arratia, B. Karki, **Comparison of point cloud and image-based models for calorimeter fast simulation**, JINST 19 (2024) 05, P05003.

11 CMS Collaboration, **Search for pair-produced vector-like leptons in final states with third-generation leptons and at least three b quark jets in proton-proton collisions at $\sqrt{s} = 13$ TeV**, Phys. Lett. B 846 (2023) 137713.

12 H1 Collaboration, **Unbinned Deep Learning Jet Substructure Measurement in High Q^2 ep collisions at HERA**, Phys. Lett. B 844 (2023) 138101.

13 V. Mikuni, B. Nachman, M. Pettee, **Fast point cloud generation with diffusion models in high energy physics**, Phys. Rev. D 108 (2023) 3, 036025.

14 L. Gouskos, F. Iemmi, S. Liechti, B. Maier, V. Mikuni, **Optimal transport for a novel event description at hadron colliders**, Phys. Rev. D 108 (2023) 9, 096003.

15 G. Kasieczka, R. Mastandrea, V. Mikuni, B. Nachman, M. Pettee, **Anomaly detection under coordinate transformations**, Phys. Rev. D 107 (2023) 1, 015009.

16 V. Mikuni, B. Nachman, **Score-based generative models for calorimeter shower simulation**, Phys. Rev. D 106 (2022), 092009.

17 V. Mikuni, B. Nachman, D. Shih, **Online-compatible unsupervised nonresonant anomaly detection**, Phys. Rev. D 105 (2022), 055006, *Selected for the Editors' Suggestion.*

18 V. Mikuni, F. Canelli, **Point cloud transformers applied to collider physics**, Mach. Learn. Sci. Tech. 2 (2021) 3, 035027.

19 Kasieczka, Gregor and others, **The LHC Olympics 2020 a community challenge for anomaly detection in high energy physics**, Rept. Prog. Phys. 84 (2021), 124201.

20 V. Mikuni and F. Canelli, **Unsupervised clustering for collider physics**, Phys. Rev. D 103 (2020), 092007.

21 V. Mikuni and F. Canelli, **ABCNet: an attention-based method for particle tagging**, Eur. Phys. J. Plus 135 (2020).

22 CMS Collaboration, **Measurement of the** $\mathrm{t\bar{t}b\bar{b}}$ **production cross section in the all-jet final state in pp collisions at** $\sqrt{s}$ **= 13 TeV**, Phys. Lett. B (803) 2020 135285.

23 AMS Collaboration, **Observation of complex time structures in the cosmic-ray electron and positron fluxes with the Alpha Magnetic Spectrometer on the international space station**, Phys. Rev. Lett. 121 (2018), 051102.

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