Dr. Marco Lorusso, Ph.D.

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Education

2021 – 2025 **Ph.D., Physics** Alma Mater Studiorum - University of Bologna.
Thesis title: *Optimization of ML-Based BSM triggering with Knowledge Distillation for FPGA implementation in the CMS Level-1 Trigger*
Mark: Excellent cum Laude.

2018 – 2021 **M.Sc. Physics** Alma Mater Studiorum - University of Bologna.
Thesis title: *FPGA implementation of muon momentum assignment with Machine Learning at the CMS Level-1*
Mark: 110/110 cum Laude.

2015 – 2018 **B.Sc. Physics** Alma Mater Studiorum - University of Bologna.
Thesis title: *Combined use of Drift Tubes and Resistive Plate Chambers information in the CMS Muon Barrel Trigger*
Mark: 109/110.

Research Activities

Machine Learning — **Artificial Neural Networks** and their use in High Energy Physics, focusing on **Anomaly Detection** for the search of physics beyond the Standard Model, as part of the CMS Collaboration at CERN, using Convolutional **AutoEncoders**, Variational AutoEncoders and **Graph Neural Networks**.

Heterogeneous Computing — Set up and test of **FPGA accelerator cards** on server. Cutting edge **optimization** of Neural Networks for deployment on FPGA using **Knowledge Distillation** and HLS.

Quantum Computing — Development of algorithms for **Quantum Computers with annealing technology**. Creation of a ready-to-use **Docker container** for development of quantum applications using quantum simulations and real hardware when available in cloud. Use of Autoencoder for **Quantum Error Mitigation** on gate based QPUs.

Skills

Languages — **English** Reading, writing and speaking competencies at C2 level (IELTS 8.0, Dec 2020).
French Basic reading and speaking competencies.

Coding — Python, C++, C, LaTeX, HLS, OpenCL, VHDL, Bash, Docker, OpenGL.
Libraries: TensorFlow/Keras, hls4ml, Numpy, Scipy, XGBoost ...

Programs — Vitis, Vivado, MadGraph, LabVIEW, OBS Studio, Audacity

Web Dev — HTML, CSS, Markdown, JavaScript.

Teaching Activities

2023 **Hands-on Facilitator** National Institute for Nuclear Physics for Italian Research Center on High Performance Computing, Big Data and Quantum Computing (ICSC), *Introductory course to HLS FPGA programming*, Online.

2022 **Laboratory Tutor** Alma Mater Studiorum - University of Bologna, Physics Department, First cycle degree, Laboratory of Electronics course, Bologna, Italy.

Program Consultant, IT Support, Lecturer National Institute for Nuclear Physics, *Tecniche Di Machine Learning Con Dispositivi FPGA per Gli Esperimenti Di Fisica Delle Particelle* Workshop, Bologna, Italy.

2021 **Laboratory Tutor** Alma Mater Studiorum - University of Bologna, Physics Department, First cycle degree, Laboratory of Mechanics and Thermodynamics course, Bologna, Italy.

Awards and Scholarships

2023 – 2024 **CERN Doctoral Student** *FPGA implementation of Machine Learning algorithms for the CMS Level-1 trigger*, Geneve, Switzerland.

2022 **Best poster award**, *Accelerazione di algoritmi di Machine Learning con FPGA su INFN Cloud e su Cloud pubbliche*, Workshop sul Calcolo nell'I.N.F.N, Paestum, Italy.

Conferences and Workshops

2024 **22nd International Workshop on Advanced Computing and Analysis Techniques in Physics Research** (ACAT2024), Parallel Speaker, Stony Brook, NY, USA.

2023 **26th International Conference on Computing in High Energy & Nuclear Physics** (CHEP2023), Parallel Speaker, Jefferson Lab, Norfolk, VA, USA.

20th International Symposium on Grids & Clouds (ISGC2023), Parallel Speaker, Academia Sinica, Taiwan, Taipei.

2022 **21st International Workshop on Advanced Computing and Analysis Techniques in Physics Research** (ACAT2022), Parallel Speaker, Bari, Italy.

41st International Conference on High Energy Physics (ICHEP2022), Parallel Speaker, Bologna, Italy.

Workshop sul Calcolo nell'I.N.F.N., Poster, Istituto Nazionale di Fisica Nucleare, Paestum, Italy.

2023 **19th International Symposium on Grids & Clouds** (ISGC2022), Parallel Speaker, Academia Sinica, Taiwan, Taipei.

Research Publications

Main Publications

1. G. Bianco, S. Gasperini, and **M. Lorusso**, "QUnfold: Quantum Annealing for Distributions Unfolding in High-Energy Physics," *Journal of Physics: Conference Series*, vol. ACAT 2024, Under peer review. To be published. URL: https://indico.cern.ch/event/1330797/contributions/5796497.

2. **M. Lorusso**, "Optimizing ANN-Based Triggering for BSM events with Knowledge Distillation," *Journal of Physics: Conference Series*, vol. ACAT 2024, Under peer review. To be published. URL: https://indico.cern.ch/event/1330797/contributions/5796612.

3. **M. Lorusso**, D. Bonacorsi, and R. Travaglini, "Implementing Machine Learning inference on FPGAs: from software to hardware using hls4ml," *Journal of Physics: Conference Series*, vol. ACAT 2022, Accepted. To be published. URL: https://indico.cern.ch/event/1106990/contributions/4991291.

4. F. Minarini and **M. Lorusso**, "Energy consumption characterization of Subnuclear Physics computing workloads," *Journal of Physics: Conference Series*, vol. ACAT 2024, Under peer review. To be published. URL: https://indico.cern.ch/event/1330797/contributions/5796570.

5. **M. Lorusso**, D. Bonacorsi, R. Travaglini, *et al.*, "Scalable training on scalable infrastructures for programmable hardware," *EPJ Web Conf.*, vol. CHEP 2023, May 2024. DOI: 10.1051/epjconf/202429508014.

6. **M. Lorusso**, D. Bonacorsi, D. Salomoni, *et al.*, "Accelerating Machine Learning inference using FPGAs: the PYNQ framework tested on an AWS EC2 F1 Instance," *PoS*, vol. ICHEP2022, Jun. 2023. DOI: 10.22323/1.414.0243.

7. **M. Lorusso**, D. Bonacorsi, R. Travaglini, *et al.*, "Scalable training on scalable infrastructures for programmable hardware," *PoS*, vol. ISGC & HEPiX2023, Oct. 2023. DOI: 10.22323/1.434.0022.

8. L. Valente, L. Anzalone, **M. Lorusso**, and D. Bonacorsi, "Joint Variational Auto-Encoder for Anomaly Detection in High Energy Physics," *PoS*, vol. ISGC & HEPiX2023, Oct. 2023. DOI: 10.22323/1.434.0014.

9. **M. Lorusso**, D. Bonacorsi, D. Salomoni, and R. Travaglini, "Machine Learning inference using PYNQ environment in a AWS EC2 F1 Instance," *PoS*, vol. ISGC2022, Sep. 2022. DOI: 10.22323/1.415.0001.

10. T. Diotalevi, **M. Lorusso**, R. Travaglini, C. Battilana, and D. Bonacorsi [CMS Collaboration], "Deep Learning fast inference on FPGA for CMS Muon Level-1 Trigger studies," *PoS*, vol. ISGC 2021, Oct. 2021. DOI: 10.22323/1.378.0005.

Thesis Supervision

1. M. Vassallo, "Machine learning for quantum error mitigation on NISQ devices," Bachelor's Thesis, Alma Mater Studiorum - University of Bologna, 2024. URL: http://amslaurea.unibo.it/32365.

2. L. Valente, "A variational autoencoder application for real-time anomaly detection at CMS," Master's Thesis, Alma Mater Studiorum - University of Bologna, 2023. URL: http://amslaurea.unibo.it/28788.

For all publications as CMS Collaborator, see Inspire HEP author page @ https://inspirehep.net/authors/1950751

Declaration in lieu of notoriety (art. 47 D.P.R. 28/12/2000 n. 445): aware of the penalties, in the case of false statements and false documents, as per art. 76 of Presidential Decree n. 445/2000 of 28/12/2000, I declare that the information provided in this curriculum vitae, including the information about the professional activity performed, is true.
I hereby authorize the processing of the personal data contained in this CV in compliance with the European Regulation (UE) 2016/679.

Bologna, 03/04/2025