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.

Computing Node Setup   🔖 Prototype setup of a **computing node** for the **Einstein Telescope** experiment, built on a **JupyterHub** environment with **IAM**-based authentication and integrated with services such as **CVMFS** and **RUCIO**.

Log Analytics and Observability   🔖 Research and development of a **log analytics and observability pipeline** for large-scale distributed services at the **CNAF division of INFN**. Operational logs and metrics collected via **Filebeat**, indexed and analyzed with **Logstash** and **OpenSearch**, and time-series data stored in **InfluxDB**, supporting service monitoring, pattern analysis, and anomaly investigation.

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
Distributed Systems & Monitoring	Filebeat, Logstash, OpenSearch, InfluxDB, Grafana.
Web Dev	HTML, CSS, Markdown, JavaScript.

Research and Teaching Experience

2025 — **Research Fellow**, INFN - National Institute for Nuclear Physics, CNAF Division, Bologna, Italy. *Classical and Innovative Techniques for Predictive Maintenance in a Data Center* and *FPGA Accelerator Card Integration and Validation for Cloud-Enabled High-Performance Computing Environments (HPC Bubbles).*

Teaching Assistant Academia Sinica, International Symposium on Grids & Clouds (ISGC2025), AI Master Class - Dive into artificial intelligence by applying machine learning and deep learning techniques to real life datasets!, Taiwan, Taipei.

Teaching Assistant Alma Mater Studiorum - University of Bologna, Physics Department, Second cycle degree programme (MSc) in Physics, Software and Computing for Nuclear and Subnuclear Physics course, Bologna, Italy.

Laboratory Tutor Alma Mater Studiorum - University of Bologna, Physics Department, First cycle degree programme (BSc) in Physics, Laboratory of Electronics course, Bologna, Italy.

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 programme (BSc) in Physics, 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 programme (BSc) in Physics, Laboratory of Mechanics and Thermodynamics course, Bologna, Italy.

Awards and Scholarships

2025 — **Breakthrough Prize in Fundamental Physics** as part of the CMS Collaboration.

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

2025   🔖 **22nd International Symposium on Grids & Clouds** (ISGC2025), Parallel Speaker and Teaching Assistant for Masterclass on Artificial Intelligence, Academia Sinica, Taiwan, Taipei.

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.

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

Research Publications

Main Publications

1   **M. Lorusso**, "Optimization of ML-Based BSM triggering with knowledge distillation for FPGA implementation in the CMS Level-1 trigger," *Alma Mater Studiorum - University of Bologna, Ph.D Dissertation*, Mar. 2025. 🔗 DOI: 10.48676/unibo/amsdottorato/11891.

2   S. Gasperini, G. Bianco, **M. Lorusso**, C. Rieger, and M. Grossi, "Optimization-based unfolding in high-energy physics," 2026. arXiv: 2602.22776 [quant-ph]. 🔗 URL: https://arxiv.org/abs/2602.22776.

3   **M. Lorusso**, "Optimization of ML-Based BSM triggering with Knowledge Distillation for FPGA implementation," *PoS*, vol. ISGC2025, p. 018, 2025. 🔗 DOI: 10.22323/1.488.0018.

4   V. Brugnami, S. Gasperini, **M. Lorusso**, G. Bianco, and M. Franchini, "Study and application of QUnfold, an innovative Quantum Annealing-based Unfolding tool, using simulated ATLAS data," in *International Conference on Quantum Communications, Networking, and Computing*, Mar. 2025. 🔗 DOI: 10.1109/QCNC64685.2025.00100.

5   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, 2024, Accepted. To be published. 🔗 URL: https://indico.cern.ch/event/1330797/contributions/5796497.

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

7   **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.

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

9 **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`.

10 **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`.

11 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`.

12 **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`.

13 **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, 2022, Accepted. To be published. 🔗 URL: `https://indico.cern.ch/event/1106990/contributions/4991291`.

14 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`

Bologna, 03/02/2026