Tommaso Diotalevi

Ph.D. Student in Physics

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Dichiarazione sostitutiva di certificazione (art. 46 e 47 D.P.R. 445/2000)
Il sottoscritto **Tommaso Diotalevi**, consapevole che le dichiarazioni false comportano l'applicazione delle sanzioni penali previste dall'art. 76 del D.P.R. 445/2000, dichiara che le informazioni riportate nel seguente curriculum vitae, corrispondono a verità.

Education and training

Jan 2020 – Today — **Attendance to the activities CSN-5 "ML_INFN" ("ML_INFN: end-to-end approach to the usage of Machine Learning for INFN research topics")**.
Bologna operational unit (coordinated by Prof. D.Bonacorsi)
ML/DL modelling, DL on FPGA, CNAF predictive maintenance

Nov 2018 – Today — **Ph.D. Student in Physics**, *Alma Mater Studiorum - University of Bologna*, Bologna.
Field of research: Nuclear and Subnuclear Physics
Supervisor: Prof. Daniele Bonacorsi
Member of the CMS Collaboration since 2016.

Sep 2018 – Oct 2018 — **Technological Summer Student fellowship program**, *INFN-CNAF*.
Bologna, Italy

Jul 2016 – Sep 2016 — **CERN Summer Student Programme**.
CERN, Switzerland
Project report: "*Analysing CMS transfers using Machine Learning techniques*"

Oct 2015 – Jul 2018 — **Master Degree in Physics**, *University of Bologna*, Bologna.
Curriculum: Nuclear and Subnuclear Physics
Final Mark: 110/110 cum laude
Thesis in the CMS experiment: *CMS Level-1 Trigger Muon Momentum assignment with Machine Learning*, supervised by Prof. Daniele Bonacorsi and co-supervised by Prof. Luigi Guiducci and Dr. Carlo Battilana

Oct 2012 – Oct 2015 — **Bachelor Degree in Physics**, *University of Bologna*, Bologna.
Final Mark: 110/110 cum laude
Thesis in the CMS experiment: *Investigation of Petabyte-scale data transfer performances with PhEDEx for the CMS experiment*, supervised by Prof. Daniele Bonacorsi

Sep 2007 – Oct 2012 — **Scientific High School Diploma**, *"G.Marconi" Scientific High School*, Pesaro.
Final Mark: 96/100

Participation to physics schools

23-30 Sep 2020 — **CMS Virtual Data Analysis School (CMSDAS)**.
CERN, Switzerland

20-24 Jul 2020 — **Physical Sensing and Processing**.
Bologna, Italy

22-23 Jan 2020 — **CERN Openlab Technical Workshop**.
CERN, Switzerland

16-20 Sep 2019 **Third International School on Open Science Cloud, SOSC2019**.
Bologna, Italy
Personal contribution: Awarded with the second prize on the Machine Learning Kaggle competition organised by the school

2-7 Jun 2019 **INFN School of Statistics 2019**.
Paestum, Salerno
Personal contribution: Awarded with the first prize on the Machine Learning Kaggle competition organised by the school

6 Feb 2019 **How to do ultrafast Deep Neural Network inference on FPGAs**.
Zurich, Switzerland

11-15 Apr 2016 **2nd BCD International School on High Energy Physics (ISHEP)**.
Cargese, France

Scolarships and contracts

Jan 2016 – Today **Member of the CMS Collaboration (Compact Muon Solenoid)**.
CERN, Switzerland

Nov 2019 – Feb 2020 **Corporate consultant in the Oper CBI project**.
Bologna, Italy

Feb 2019 – Today **CERN contract of association**.
CERN, Switzerland

Nov 2018 – Today **INFN Ph.D. Scholarship**, *INFN Bologna*, Italy.

Sep 2018 – Oct 2018 **INFN-CNAF Technological Summer Student fellowship scholarship**.
Bologna, Italy

Nov 2018 – Today **INFN (National Institution for Nuclear and Subnuclear Physics - Bologna section) contract of association**.
Bologna, Italy

Personal contribution at conferences

Oral contribution

- **International Symposium on Grids & Clouds 2020, ISGC2020**
  8 March - 13 March 2020, Taipei (Taiwan) [Cancelled due to Covid-19 pandemic]
- **International Symposium on Grids & Clouds 2019, ISGC2019**
  31 March - 5 April 2019, Taipei (Taiwan)
  Title: *Collection and harmonization of system logs and prototypal Analytics services with the Elastic (ELK) suite at the INFN-CNAF computing centre*
  Proceeding published for publication on PoS: PoS(ISGC2019)027

Poster contribution

- **6th Annual Conference on Large Hadron Collider Physics (LHCP2018)**
  4-9 June 2018, Bologna (Italy). - Main author
  Title: *Development of Machine Learning based muon trigger algorithms for the Phase2 upgrade of the CMS*
  Proceeding published for publication on PoS: PoS(LHCP2018)092

- **21st International Conference on Computing in High Energy and Nuclear Physics, CHEP2015**, 13-17 April 2015 (Okinawa, Japan). - Coauthor
  Title: *Monitoring data transfer latency in CMS computing operations*
  Proceeding published for publication on Journal of Physics: 664(3):032033, 2015

Research activities

PHYSICS ANALYSIS

- **Search for MSSM Higgs Boson decaying to $\mu^+\mu^-$ in pp collisions at $\sqrt{s} = 13TeV$**
  (Nov 2018 - Today)
  I joined this group in November 2018. The CMS collaboration on this particular analysis, before my arrival, has published the following paper: CMS-HIG-18-010 (arXiv:1907.03152). My personal contribution is related to the following steps of such analysis, with the inclusion of the entire Run2 data at a center-of-mass energy of 13TeV. In particular, using the TMVA package of ROOT, I am involved in the production of Machine and Deep Learning algorithms for the improvement of the signal/background discrimination, compared to the "classical" cut-based approach.

MUON POG

- **Run3 High p_T classifier with Machine Learning**
  (Mar 2020 – Today)
  I started collaborating with the CMS Muon POG L3 subgroups, studying possible refit techniques for high p_T muons, using Machine Learning techniques. If results will be promising, the algorithm developed will replace the actual algorithm for the choice of the best refit, TuneP, improving the overall muon high p_T assignment.

SOFTWARE & COMPUTING

- **Collection of system logs and prototypal analytics services with the Elastic (ELK) suite at the INFN-CNAF computing centre**
  (Nov 2018 – Apr 2019)
  The distributed Grid infrastructure for High Energy Physics experiments at the Large Hadron Collider (LHC) in Geneva comprises a set of computing centres, spread all over the world, as part of the Worldwide LHC Computing Grid (WLCG). In Italy, the Tier-1 functionalities are served by the INFN-CNAF data center, which provides also computing and storage resources to more than twenty non-LHC experiments. For this reason, a high amount of logs are collected each day from various sources, which are highly heterogeneous and difficult to harmonize. During my work at the INFN-CNAF, I started working on a centralised system that collects, parses and displays the log information from CNAF data sources, investigating them on a Machine Learning based predictive maintenance system.

- **Monitoring data transfer latency in CMS computing operations**
  (Jan 2015 – Oct 2015)
  I worked in the PhEDEx group, analysing several typical CMS transfer workflows, such as distribution of collision event data from CERN or upload of simulated event data from the Tier-2 centres to the archival Tier-1 centres. For each workflow, the typical patterns of transfer latencies that have been identified with the latency monitor, were identified; in particular the areas in PhEDEx where a development effort can reduce the latency, showing the ability to detect stuck transfers which need operator intervention. A set of metrics was created to alert about stuck subscriptions and prompt for manual intervention, with the aim of improving transfer completion times.

DETECTOR R&D

- **Development of a Machine Learning based muon trigger algorithm for the Phase2 upgrade of the CMS detector**
  (Jul 2017 – Jul 2018)
  After the high-luminosity upgrade of the LHC, the muon chambers of CMS Barrel must cope with an increase in the number of interactions per bunch crossing. Therefore, new algorithmic techniques for data acquisition and processing will be necessary in preparation for such a high pile-up environment. Using Machine Learning as a technique to tackle this problem, my work was mainly focused on the production of models - with data obtained through Monte Carlo simulations - capable of predicting the transverse momentum of muons crossing the CMS Barrel muon chambers, comparing them with the transverse momentum assigned by the current CMS Level-1 trigger system.

HARDWARE ACCELERATORS

- **Exploring Deep Learning fast inference on an ATCA processor board with Xilinx Virtex-7 FPGA**
  (Feb 2019 – Today)
  Both the University of Bologna and INFN-Bologna created this group with the idea of building and testing Machine and Deep Learning models into custom FPGA firmware. This kind of expertise is crucial in the future steps of High Energy Physics, in particular with low-latency hardware solutions like trigger and data acquisition that will cope with stricter requirements from the upcoming Run-3 as well as the new phase of operations with the High-Luminosity LHC. My work in this group is mainly focused with the application of the High-Level Synthesis toolkit - hls4ml - developed mainly at CERN, to convert simple neural networks into a series of logic operations and testing them on a high end ATC136 board with a Xilinx Virtex-7 FPGA.

Teaching and Outreach

25 Sep 2020 **Co-supervisor**, *master student degree in Physics*.
University of Bologna
Title: *Search for Beyond Standard Model neutral Higgs boson in the $\mu\mu$ channel with the CMS detector at LHC with a multivariate approach*

Mar 2020 – Sep 2020 **Academic Tutor**, *"Applied Machine Learning - Advanced" course*.
Department of Physics and Astronomy, *University of Bologna*

Nov 2019 – June 2020 **Academic Tutor**, *"General Physics T-1" course*.
Department of Physics and Astronomy, *University of Bologna*

18 Oct 2019 **Co-supervisor**, *bachelor student degree in Physics*.
University of Bologna
Title: *Search for neutral MSSM Higgs bosons with CMS at LHC: a comparison between a cut-based analysis and a Machine Learning approach*

27 Sep 2019 **European Night of Researchers**, *Artificial Intelligence for High Energy Physics*.
Bologna, Italy

Jul 2019 **Tutor**, *High school study/work experience*.
Bologna, Italy
Project developed by the "*Comitato di Coordinamento III missione (cc3m)*" of the INFN, focused on outreach for general audience and young students from High Schools

Mar 2019 – May 2019 **Academic Tutor**, *"Software and Computing for Nuclear and Subnuclear Physics" course*.
Department of Physics and Astronomy, *University of Bologna*

28 Sep 2018 **European Night of Researchers**, *Artificial Intelligence for High Energy Physics*.
Bologna, Italy

Personal skills

Linguistic skills

Italian: Mother tongue

English: TOEFL iBT (level B2)

- Understanding (listening): C1
- Understanding (reading): B2
- Speaking (Spoken interaction): B2
- Speaking (Spoken production): B2
- Writing: B2

Technical skills

Op. Systems	Microsoft Windows, MacOS, Linux	Software	CMSSW, ROOT Framework, TMVA, RooFit
Languages	C++, Python, R, LabVIEW	Document editing	Microsoft Office package, LaTeX and Beamer, Overleaf
Libraries and Tools	Tensorflow, Keras, Pytorch, Jupyter, Scikit-learn, Git		

Honours and awards

- First award scholarship in Physics "*Fondazione G.Occhialini*", achieved on 07/06/2013

Scientific Publications

RELEVANT PUBLICATIONS IN TERMS OF PERSONAL CONTRIBUTION

[1] D. Bonacorsi et al. "Monitoring data transfer latency in CMS computing operations". In: *J. Phys. Conf. Ser.* 664.3 (2015), p. 032033. DOI: 10.1088/1742-6596/664/3/032033.

[2] Daniele Bonacorsi et al. "Progress in Machine Learning Studies for the CMS Computing Infrastructure". In: *PoS* ISGC2017 (2017), p. 023. DOI: 10.22323/1.293.0023.

[3] Daniele Bonacorsi et al. "Progress on Machine and Deep Learning applications in CMS Computing". In: *PoS* ISGC2018 (2018), p. 022. DOI: 10.22323/1.327.0022.

[4] T. Diotalevi, D. Bonacorsi, et al. "Collection and harmonization of system logs and prototypal Analytics services with the Elastic (ELK) suite at the INFN-CNAF computing centre". In: *Proceedings of Science* ISGC2019 (2019), p. 027. DOI: 10.22323/1.351.0027.

[5] L. Giommi, T. Diotalevi, D. Bonacorsi, et al. "Towards Predictive Maintenance with Machine Learning at the INFN-CNAF computing centre". In: *Proceedings of Science* ISGC2019 (2019), p. 003. DOI: 10.22323/1.351.0003.

[6] Diotalevi Tommaso et al. "Development of Machine Learning based muon trigger algorithms for the Phase2 upgrade of the CMS ". In: *PoS* LHCP2018 (2018), p. 092. DOI: 10.22323/1.321.0092.

LIST OF PUBLICATIONS SUBMITTED TO OR PUBLISHED ON INTERNATIONAL PEER REVIEW JOURNALS

[1] Albert M Sirunyan et al. "A search for bottom-type, vector-like quark pair production in a fully hadronic final state in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (Aug. 2020). arXiv: 2008.09835 [hep-ex].

[2] Albert M Sirunyan et al. "Evidence for electroweak production of four charged leptons and two jets in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (Aug. 2020). arXiv: 2008.07013 [hep-ex].

[3] Albert M Sirunyan et al. "Evidence for top quark production in nucleus-nucleus collisions". In: (June 2020). arXiv: 2006.11110 [hep-ex].

[4] Albert M Sirunyan et al. "Inclusive search for highly boosted Higgs bosons decaying to bottom quark-antiquark pairs in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (June 2020). arXiv: 2006.13251 [hep-ex].

[5] Albert M Sirunyan et al. "Measurement of $\mathrm{B_c(2S)^+}$ and $\mathrm{B_c^*(2S)^+}$ cross section ratios in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (Aug. 2020). arXiv: 2008.08629 [hep-ex].

[6] Albert M Sirunyan et al. "Measurement of differential $\mathrm{t\bar{t}}$ production cross sections using top quarks at large transverse momenta in pp collisions at $\sqrt{s} = 13$ TeV". In: (Aug. 2020). arXiv: 2008.07860 [hep-ex].

[7] Albert M Sirunyan et al. "Measurement of the CP-violating phase ϕ_s in the $\mathrm{B_s^0} \to \mathrm{J}/\psi\,\phi(1020) \to \mu^+\mu^-\mathrm{K^+K^-}$ channel in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (July 2020). arXiv: 2007.02434 [hep-ex].

[8] Albert M Sirunyan et al. "Measurements of production cross sections of WZ and same-sign WW boson pairs in association with two jets in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (May 2020). DOI: 10.1016/j.physletb.2020.135710. arXiv: 2005.01173 [hep-ex].

[9] Albert M Sirunyan et al. "Measurements of the W boson rapidity, helicity, double-differential cross sections, and charge asymmetry in pp collisions at $\sqrt{s} = 13$ TeV". In: (Aug. 2020). arXiv: 2008.04174 [hep-ex].

[10] Albert M Sirunyan et al. "Observation of electroweak production of Wγ with two jets in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (Aug. 2020). arXiv: 2008.10521 [hep-ex].

[11] Albert M Sirunyan et al. "Observation of the $\mathrm{B_s^0} \to$X(3872)ϕ decay". In: (May 2020). arXiv: 2005.04764 [hep-ex].

[12] Albert M Sirunyan et al. "Observation of the production of three massive gauge bosons at $\sqrt{s} = 13$ TeV". In: (June 2020). arXiv: 2006.11191 [hep-ex].

[13] Albert M Sirunyan et al. "Reconstruction of signal amplitudes in the CMS electromagnetic calorimeter in the presence of overlapping proton-proton interactions". In: (June 2020). arXiv: 2006.14359 [physics.ins-det].

[14] Albert M Sirunyan et al. "Search for a light charged Higgs boson in the $\mathrm{H^\pm} \to$ cs channel in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (May 2020). arXiv: 2005.08900 [hep-ex].

[15] Albert M Sirunyan et al. "Search for a light pseudoscalar Higgs boson in the boosted $\mu\mu\tau\tau$ final state in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (May 2020). arXiv: 2005.08694 [hep-ex].

[16] Albert M Sirunyan et al. "Search for dark matter produced in association with a leptonically decaying Z boson in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: (Aug. 2020). arXiv: 2008.04735 [hep-ex].

[17] Albert M Sirunyan et al. "Search for decays of the 125 GeV Higgs boson into a Z boson and a ρ or ϕ meson". In: (July 2020). arXiv: 2007.05122 [hep-ex].

[18] Albert M Sirunyan et al. "Search for disappearing tracks in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: *Phys. Lett. B* 806 (2020), p. 135502. DOI: 10.1016/j.physletb.2020.135502. arXiv: 2004.05153 [hep-ex].

[19] Albert M Sirunyan et al. "Search for resonant pair production of Higgs bosons in the bbZZ channel in proton-proton collisions at $\sqrt{s} = 13$ TeV". In: *Phys. Rev. D* 102.3 (2020), p. 032003. DOI: 10.1103/PhysRevD.102.032003. arXiv: 2006.06391 [hep-ex].

[20] Albert M Sirunyan et al. "Search for supersymmetry in proton-proton collisions at $\sqrt{s} = 13$ TeV in events with high-momentum Z bosons and missing transverse momentum". In: (Aug. 2020). arXiv: 2008.04422 [hep-ex].

[21] Albert M Sirunyan et al. "Search for top squark pair production using dilepton final states in pp collision data collected at $\sqrt{s} = 13$ TeV". In: (Aug. 2020). arXiv: 2008.05936 [hep-ex].