

Andrea Carlo Marini

Curriculum Vitae

Personal Information

Home Institute Massachusetts Institute of Technology (MIT), Cambridge, MA
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Alma mater Eidgenössische Technische Hochschule (ETH), Zürich (2015)
Date of Birth 26th February 1987
Citizenship Italian

Education

2011–2015 **PhD in physics**, *ETH*, Zürich.
Thesis advisor Prof. Günther Dissertori.
2006–2011 **Diploma di Licenza**, *Scuola Normale Superiore*, Pisa, 70/70 cum laude.
Student with Grant
2009–2011 **Master degree in physics**, *Università di Pisa*, Pisa, 110/110 cum laude.
Thesis advisor Prof. Luigi Rolandi.
2006–2009 **Bachelor degree in physics**, *Università di Pisa*, Pisa, 110/110 cum laude.
Thesis advisor Prof. Luigi Rolandi.

Experience

2015–today **Postdoctoral Associate**, *MIT*, c/o CERN.
As a postdoctoral associate at MIT and visiting scientist at CERN, I maintain the CMS detector, develop and motivate new detectors, and analyze the collected data in order to produce scientific results; furthermore, I supervise students during their studies, reviewed and planned the scientific output of the Collaboration.
2011–2015 **Teaching Assistant**, *ETH*, Zürich.
I participate in quality of teaching assistant in lectures on classical mechanics, classical electrodynamics, nuclear physics, and physics laboratory for students of the first and second year of college.
2011–2015 **PhD Student**, *ETH*, Zürich.
As a doctoral student and visiting scientist at CERN, I maintain the CMS detector, develop and motivate new detectors, and analyze the collected data in order to produce a scientific output.

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Abilitazione Scientifica Nazionale – Italy

2018–2024 **ASN**, *Seconda fascia*, Settore FIS 02/A1.

I obtained the “Abilitazione scientifica nazionale a professore di seconda fascia” in the section FIS 02/A1 from 05/10/2018 to 05/10/2024.

Languages

Italian Mother tongue
English Advanced level
French Basic level

Scientific Appointments

2018–2019 Peer Review for

- **PLB** (2019)
- **Advances in High Energy Physics** (2019)
- **JHEP** (2018)

2018–today Convener of the Higgs Combination and Properties: *The Higgs combination and properties conveners supervise the operation in the Higgs combination group, coordinating efforts among the Higgs sub-groups, and supporting and assuring that the single channel analyses are ready to be combined in order to give a broader physics message.*

2017–today Member of the Statistical Committee: *The CMS Statistical Committee overviews the scientific output of the CMS Collaboration, providing guidance on statistical problems, and reviewing the correctness of the statistical procedure of the results submitted for publication.*

2016–today Coordinator of the CMS Quark Gluon Jet group: *As coordinator of the quark-gluon jet studies, I manage the efforts of students and researcher on the matter of discrimination between quark and gluon initiated jets, providing continuity of the solutions found and assuring up to date taggers to the analyzers in the CMS Collaboration*

2015–today Analysis Review Committee (ARC): *The CMS ARCs assure the correctness of the physics results on specific analyses and follow them providing suggestions and improvements on the different problematic. I served as a member in the following analyses:*

- CMS-PAS-HIG-15-005, *First results on the Higgs to diphoton at 13 TeV*
- CMS-PAS-HIG-16-020, *Higgs to diphoton measurements at 13 TeV using 2016 data*
- CMS-SMP-16-016, *Measurement of triple differential cross section of photon+jet at 8 TeV*
- CMS-HIG-17-025, *Higgs to diphoton differential and fiducial cross-sections with 2016 dataset (Pub. in **JHEP** 01 (2019) 183)*
- CMS-HIG-17-028, *Combination of fiducial differential cross-sections with 2016 dataset (Pub. in **PLB** 792 (2019) 369)*
- CMS-PAS-HIG-18-029, *Higgs to gamma gamma stage1 STXS*

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Scientific Experience

Precision measurements in the standard model

During my years in CMS, I contributed to different precision measurements testing the standard model (SM) of particle physics, especially focusing on the electroweak (EW) vector bosons (W, Z, γ).

Starting in 2011, I contributed as the main analyzer to the measurement of the angular properties of the associated production of Z+jets at $\sqrt{s} = 7$ TeV in order to validate the Monte Carlo (MC) generators used at the time for their usage on the extrapolation in phase space region used in searches of physics beyond the SM (BSM) [plb13]. The study started with the preliminary evaluation of possible discriminating variables between the different MC models, the comparison of them with the 2011 CMS collected data, and the subtraction of irreducible backgrounds, the impact and the un-smearing of the detector effects ("unfolding") and the investigation of possible sources of systematic uncertainties associated to the measurement.

Later in 2014–2015, I studied the ratio of the differential production cross section of the Z+jets over photon+jet at $\sqrt{s} = 8$ TeV [jhep15, ichep1, ichep2]. This measurement is important in the search for BSM physics, where the γ spectrum is used as a proxy for the Z to invisible ones. It also provided data to validate the later on developed NNLO calculation of the γ +jets production in pp collisions. In this analysis, I took care of the photon+jet measurement, the reducible background evaluation due to the misidentification of jets (π^0 , η) into photons, to the evaluation of systematic uncertainties associated. Moreover, I also took care of the extraction of the Z over γ production cross section ratio and the statistical procedure associated to the measurement. During the period of 2015–2016, I collaborate to the inclusive and differential measurement of the W and Z production, taking care of the un-smearing of detector effects and the validation of the irreducible backgrounds due to the top production [CMS-PAS-SMP-15-004, CMS-PAS-SMP-15-011, moriond1]. I also port the new Geneva MC generator in preliminary comparison with CMS data, reviving and fixing the CMS reconstruction starting from the HepMC data format, that is now used by similar flows as well. Later, I contribute in comparing Geneva MC generator to the 2016 differential measurements [CMS-PAS-SMP-17-010].

Search and measurements of the Higgs boson

The discovery of the existence of the Higgs boson from the CMS and ATLAS Collaborations [plb12] opened the need to study its properties and its compatibility with the SM predictions. During 2013–2014, I contributed to the measurement that brought to the discovery of the Higgs decaying into a diphoton pair [epjc14, prl15]. Taking advantage of the acquired expertise in both the SM precision measurement and in the Higgs signal extraction, I played a leading role in designing and performing the differential and fiducial cross section measurements of the Higgs into diphoton [epjc16]. Design that has been later widely used in the CMS Higgs results and this methodology was reported as well in CERN Yellow Report [cyrm17], in order to establish a common and shared standard between ATLAS and CMS Collaborations.

During the year 2017, I joined the CMS Higgs to dimuon efforts, becoming shortly the leading person of the analysis [prl19, moriond2], convening the $H \rightarrow \mu\mu$ SM and BSM effort for 2017–2018 period; the dimuon channel probes for the first time the coupling of the Higgs boson to the fermions of the second generation with the goal to establish or disprove the SM nature of this particle. The main challenges arise from the high irreducible background coming from the Drell–Yan (DY) and top pair production processes, on top of which a tiny signal peak is looked for. The unknown shapes of the DY spectrum at the desired precision ($< 0.1\%$), including detector effects, poses the limiting factor in the extraction of the dominant signal production (gluon-gluon fusion). These studies were

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expanded in the prospects for the high luminosity LHC (HL-LHC) and I contributed to the sensitivity projections of the Higgs boson couplings that contribute to motivate the project [arXiv1902]. The BSM search looks for a clear final state where the presence of additional resonances is searched on a broader spectrum in gluon-gluon fusion or bottom quark associated productions [arXiv1907]. During 2018, I become convener of the Higgs combination and properties group, and I started to overview the effort of producing coupling measurements for the full Run 2 dataset, and I had a important role in producing the preliminary couplings measurements with the full dataset.

Searches for Charged Higgs bosons

The charged Higgs bosons appear in models that introduce new doublets (2HDM) or triplets Higgs fields. A discovery of a new charged particle will point directly into BSM scenarios, decoupling it from the complexity of the models. The effort of the MIT group on the charged Higgs bosons searches involves the decay channels in τ leptons ($H^\pm \rightarrow \tau \nu_\tau$) both decaying hadronically and leptonically [JHEP19, CMS-PAS-HIG-16-031], and the decay channel in top-bottom quarks ($H^\pm \rightarrow tb$) in the single and dilepton final states [CMS-PAS-HIG-18-004], and in the boosted fully hadronic final state [CMS-PAS-HIG-18-015]. I supervised students and coordinate the work activities of the people involved in the analysis, looking for background evaluation statistical procedure and extraction of the results.

Quark-gluon jet discrimination

The development and the validation of a discriminator capable of statistically distinguish between quark and gluon jets started with the bachelor thesis (2009) and with my master thesis (2011) with the preliminary studies on MC, in order to identify possible discriminating variables, the first data/MC comparisons at $\sqrt{s} = 7$ TeV. With this discriminator, I gained experience of the potential expressed by the particle flow (PF) reconstruction of CMS, the jet reconstruction and properties and the difficulties associated with them. It has been used for example in the discovery of the Higgs boson, in the channel $H \rightarrow ZZ \rightarrow llqq$, in order to enhance the signal over background composition, and in other searches and SM analysis. During Run 2, this tool is more and more used inside CMS analysis.

The study has been completed in 2012 (during my studies for the PhD) at $\sqrt{s} = 8$ TeV, with the detailed and systematic extraction of the uncertainty of the efficiencies for quark and gluon separately using Z+jets and dijets processes [CMS-PAS-JME-13-002].

This experience has been brought to the Run 2 of the LHC data taking supervising the reloading for the 2015 and 2016 discriminator, providing support to the analysis using it, and understanding its performances and limitations with the new data-taking conditions of the CMS detector [CMS-PAS-JME-16-003].

Calorimetry and Data acquisition system

During 2014, I developed a data acquisition package (DAQ) to be used in the CERN North Area, and in particular in the H4 beamline, where the super-proton synchrotron (SPS) delivers high energy secondary beams of electrons and pions (> 100 GeV) [JINST18]. The DAQ need to be fast (> 1 kHz), reliable, and configurable in order to ease the adaptation to the different prototypes under study and to acquire as many data as possible. It is therefore written in C++ using the CAEN library for the interface with the acquisition boards, and ZeroMQ for the network data transmission. It can include an arbitrary number of data-readout, one run-controller that synchronizes all the machines with the SPS status commands, and one event builder, that merge together the whole event and write it on disk. The performances were limited by the transmission band of the CAEN read out (40 Mb/s) and the presence of multiple digitizers in the event, not posing additional limits in the

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data acquisition. For its performances and the generality of its design, it has been used in many other test beams from 2015 to at least 2018. I also developed a software package to perform the data analysis and the energy reconstruction of the prototype of W-CeF₃ sampling calorimeter and contribute to its performance studies [nima15, jinst16].

High Granularity Calorimeter and Trigger System

CMS upgrade program for High-Luminosity (HL) LHC includes the substitution of the endcap calorimeter, with a new design based on silicon sensors posed between passive material; during 2017–2018, feasibility studies of the high granularity calorimeter (HGCAL) triggering system (L1) have been performed, providing help in the design of the trigger emulation in the CMS central framework, performing studies for the technical design report (TDR) [CMS-TDR-019], and in particular, focusing on the implementation of clustering based on the MC truth information, and on the jet triggering performances that contribute to motivate the construction of the calorimeter. Later, I contributed to the development and the studies of the e-link concentrator (ECON) in order to characterize the information loss in the data reduction in the first layer of the data-acquisition for the L1 trigger.

Conferences and seminars

- 03/2018 Plenary talk “*Rare and invisible Higgs decays in CMS*”. Recontres de Morionds: EW and Unified theories. La Thuille. Italy.
- 10/2017 Plenary talk “*H4DAQ: a modern and versatile data acquisition package for calorimeter prototypes test-beams*”. CHEF. Lyon. France.
- 11/2016 “*Charged Higgs searches in CMS*”. MIT Seminar. Boston. USA.
- 08/2016 “*Charged Higgs bosons searches at CMS*”. ICHEP. Chicago. USA.
- 03/2016 Plenary talk “*Inclusive and differential W/Z at CMS and ATLAS*”. Recontres de Moriond: QCD and high energy interactions. La Thuille. Italy.
- 11/2015 “*Unfolding procedure in the Higgs measurements (recap)*”. LHC Higg Cross section Working Group. CERN. Geneva. Switzerland.
- 06/2015 “*Unfolding procedure in the Higgs measurements*”. LHC Higg Cross section Working Group. CERN. Geneva. Switzerland.
- 07/2014 “*Measurements of Photons and Diphotons processes at CMS*”. ICHEP. Valencia. Spain.
- 07/2014 “*Z+jet over gamma+jet cross-section ratio*”. Poster. ICHEP. Valencia. Spain.
- 07/2014 “*Z+jets at CMS*”. SPS. Fribourg. Switzerland.
- 03/2014 “*Quark/Gluon Jet Discrimination*”. Poster. LHCC CERN. Geneva. Switzerland.
- 09/2013 “*Exploiting reconstructed jet properties in CMS*”. QCD@LHC. Hamburg. Germany.
- 08/2013 “*Z+Jets at CMS*”. PhD Seminar. ETH Zürich. Switzerland.
- 02/2013 Plenary talk “*V+Jets at CMS*”. Lake Louise. Canada.
- 10/2012 “*Azimuthal correlations and event shape distributions in Z+jets events in pp collisions at CMS*”. EW Working Group. CERN. Geneva. Switzerland.
- 08/2012 “*Azimuthal correlations in Z+jets events in pp collisions at CMS*”. PhD Seminar. University of Zürich. Switzerland.

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Students tutoring and supervision

- 2018–2019 Sagar Addepalli — Higgs to dimuon searches.
- 2017 Ankit Mohapatra — ASICS concentrator studies for the HGCAL upgrade.
- 2017–2018 Xinmei Niu — BSM Higgs to dimuon searches.
- 2017–2019 Miao Hu — Charged Higgs to top bottom fully hadronic studies.
- 2017 Molly Kaplan — Higgs to dimuon background studies, MIP Timing Detector performances and scoping studies.
- 2017 Hannah Diehl — Dark Photon studies in the dimuon channel at low invariant mass at CMS.
- 2016–2019 Jan Eyesermanns — Charged Higgs searches.
- 2016–2019 Georgia Rauco — Quark Gluon jet discrimination.

Teaching and lectures

- January 2019 CMS Data Analysis School, *Jet algorithms and jet substructures*, Pisa.
- November 2016 Lecture on statistics and statistical tools in CMS, Charged Higgs Workshop, MIT Boston.
- Spring 2015 Teaching assistant in the course Introduction to Nuclear Physics at ETH Zürich.
- Autumn 2014 Teaching assistant in the course Physics I for first and second year students of Environmental System Science, Agricultural and Food Sciences, and Earth Sciences at ETH Zürich.
- Spring 2014 Teaching assistant in the course Introduction to Nuclear Physics at ETH Zürich.
- Fall 2013 Teaching assistant in the course “Physik I for first year students of Physics, Mathematics, and Interdisciplinary Sciences at ETH Zürich.
- Spring 2013 Teaching assistant in the course “Physik II” for first year students of Physics, Mathematics, and Interdisciplinary Sciences at ETH Zürich.
- Fall 2012 Teaching assistant in the course Laboratory of physics for second year students of Physics, Mathematics, and Interdisciplinary Sciences at ETH Zürich.
- Spring 2012 Teaching assistant in the course “Physik II” (Classical Electrodynamics) for first year students of Physics, Mathematics, and Interdisciplinary Sciences at ETH Zürich.

Outreach

- I regularly guide visiting tour of the CMS experiment for students (high-school, master, ph.D.) and visiting guests.

References

- Prof. Gigi Rolandi, *Scuola Normale Superiore, Pisa*
- Prof. Günther Dissertori, *ETH, Zürich*
- Prof. Markus Klute, *MIT, Cambridge MA*

Publications

Selected Journal Articles

- [nima15] R. Becker et al., “Performance of a tungsten–cerium fluoride sampling calorimeter in high-energy electron beam tests”, **Nucl. Instrum. Meth. A** **804** (2015) 79, doi:10.1016/j.nima.2015.09.055, arXiv:1506.02604.
- [jinst16] T. Adams et al., “Beam test evaluation of electromagnetic calorimeter modules made from proton-damaged PbWO_4 crystals”, **JINST** **11** (2016) P04012, doi:10.1088/1748-0221/11/04/P04012.
- [plb13] CMS Collaboration, “Event shapes and azimuthal correlations in $Z + \text{jets}$ events in pp collisions at $\sqrt{s} = 7 \text{ TeV}$ ”, **Phys. Lett. B** **722** (2013) 238, doi:10.1016/j.physletb.2013.04.025, arXiv:1301.1646.
- [jhep15] CMS Collaboration, “Comparison of the $Z/\gamma^* + \text{jets}$ to $\gamma + \text{jets}$ cross sections in pp collisions at $\sqrt{s} = 8 \text{ TeV}$ ”, **JHEP** **10** (2015) 128, doi:10.1007/JHEP04(2016)010, 10.1007/JHEP10(2015)128.
- [prl15] ATLAS and CMS Collaboration, “Combined Measurement of the Higgs Boson Mass in pp Collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS and CMS Experiments”, **Phys. Rev. Lett.** **114** (2015) 191803, doi:10.1103/PhysRevLett.114.191803, arXiv:1503.07589.
- [epjc14] CMS Collaboration, “Observation of the diphoton decay of the Higgs boson and measurement of its properties”, **Eur. Phys. J. C** **74** (2014) 3076, doi:10.1140/epjc/s10052-014-3076-z, arXiv:1407.0558.
- [epjc16] CMS Collaboration, “Measurement of differential cross sections for Higgs boson production in the diphoton decay channel in pp collisions at $\sqrt{s} = 8 \text{ TeV}$ ”, **Eur. Phys. J. C** **76** (2016) 13, doi:10.1140/epjc/s10052-015-3853-3, arXiv:1508.07819.
- [plb12] CMS Collaboration, “Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC”, **Phys. Lett. B** **716** (2012) 30, doi:10.1016/j.physletb.2012.08.021, arXiv:1207.7235.
- [prl19] CMS Collaboration, “Search for the standard model Higgs boson decaying into two muons in pp collisions at $\sqrt{s} = 13 \text{ TeV}$ ”, **Phys. Rev. Lett.** **122** (2019) 021801, doi:10.1103/PhysRevLett.122.021801, arXiv:1807.06325.
- [jhep19] CMS Collaboration, “Search for charged Higgs bosons in the $H^\pm \rightarrow \tau^\pm \nu_\tau$ decay channel in proton-proton collisions at $\sqrt{s} = 13 \text{ TeV}$ ”, arXiv:1903.04560. Acc. by **JHEP**.
- [arXiv1907] CMS Collaboration, “Search for MSSM Higgs bosons decaying to $\mu^+ \mu^-$ in proton-proton collisions at $\sqrt{s} = 13 \text{ TeV}$ ”, arXiv:1907.03152. Sub. to **PLB**.

Conference Proceedings

- [leshouches] J. R. Andersen et al., “Les Houches 2015: Physics at TeV Colliders Standard Model Working Group Report”, in *9th Les Houches Workshop on Physics at TeV*

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Colliders (PhysTeV 2015) Les Houches, France, June 1-19, 2015. 2016.
arXiv:1605.04692.

- [ichep1] CMS Collaboration, A. C. Marini, “Z+jet over γ +jet cross-section ratio”, in *Proceedings, 37th International Conference on High Energy Physics (ICHEP 2014): Valencia, Spain, July 2-9, 2014*, volume 273-275, pp. 2805–2807. 2016. doi:10.1016/j.nuclphysbps.2015.10.070.
- [ichep2] CMS Collaboration, A. C. Marini, “Measurements of Photon and Diphoton production cross-sections at CMS”, in *Proceedings, 37th International Conference on High Energy Physics (ICHEP 2014): Valencia, Spain, July 2-9, 2014*, volume 273-275, pp. 1973–1978. 2016. doi:10.1016/j.nuclphysbps.2015.09.319.
- [moriond1] ATLAS, CMS Collaboration, A. C. Marini, “Inclusive and differential W/Z at CMS and ATLAS”, in *Proceedings, 51st Rencontres de Moriond on QCD and High Energy Interactions: La Thuile, Italy, March 19-26, 2016*, pp. 127–132, ARISF. ARISF, 2016.
- [jinst18] CMS Collaboration, “H4DAQ: a modern and versatile data-acquisition package for calorimeter prototypes test-beams”, **JINST** 13 (2018), no. 02, C02042, doi:10.1088/1748-0221/13/02/C02042.
- [moriond2] CMS Collaboration, A. C. Marini, “Rare decays of the Higgs boson with the CMS detector”, in *Proceedings, 53rd Rencontres de Moriond on Electroweak Interactions and Unified Theories: La Thuile, Italy, March 10-17, 2018*, pp. 117–122, ARISF. ARISF, 2018.

Physics Analysis Summaries

- [CMS-PAS-JME-13-002] CMS Collaboration, “Performance of quark/gluon discrimination in 8 TeV pp data”, Technical Report CMS-PAS-JME-13-002, CERN, Geneva, 2013. cern-cds:1599732.
- [CMS-PAS-JME-16-003] CMS Collaboration, “Jet algorithms performance in 13 TeV data”, Technical Report CMS-PAS-JME-16-003, CERN, Geneva, 2017. cern-cds:2256875.
- [CMS-PAS-SMP-15-004] CMS Collaboration, “Measurement of inclusive W and Z boson production cross sections in pp collisions at $\sqrt{s}=13$ TeV”, Technical Report CMS-PAS-SMP-15-004, CERN, Geneva, 2015. cern-cds:2093537.
- [CMS-PAS-SMP-15-011] CMS Collaboration, “Measurements of inclusive and differential Z boson production cross sections in pp collisions at $\sqrt{s}=13$ TeV”, Technical Report CMS-PAS-SMP-15-011, CERN, Geneva, 2016. cern-cds:2140105.
- [CMS-PAS-HIG-16-031] CMS Collaboration, “Search for charged Higgs bosons with the $H^\pm \rightarrow \tau^\pm \nu_\tau$ decay channel in the fully hadronic final state at $\sqrt{s}=13$ TeV”, Technical Report CMS-PAS-HIG-16-031, CERN, Geneva, 2016. cern-cds:2223865.
- [CMS-PAS-HIG-18-004] CMS Collaboration, “Search for a charged Higgs boson decaying into top and bottom quarks in proton-proton collisions at 13 TeV in events with electrons or muons”, Technical Report CMS-PAS-HIG-18-004, CERN, Geneva, 2019.

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[CMS-PAS-SMP-17-010] CMS Collaboration, “*Measurements of differential Z boson production cross sections in pp collisions at $\sqrt{s} = 13$ TeV*”, Technical Report CMS-PAS-SMP-17-010, CERN, Geneva, 2019.

[CMS-PAS-HIG-18-015] CMS Collaboration, “*Search for charged Higgs bosons decaying into top and a bottom quark in the fully hadronic final state at 13 TeV*”, Technical Report CMS-PAS-HIG-18-015, CERN, Geneva, 2019.

Public Documents

[CMS-TDR-019] CMS Collaboration, “*The Phase-2 Upgrade of the CMS Endcap Calorimeter*”, Technical Report CERN-LHCC-2017-023. CMS-TDR-019, CERN, Geneva, Nov, 2017. Technical Design Report of the endcap calorimeter for the Phase-2 upgrade of the CMS experiment, in view of the HL-LHC run.

[cym17] LHC Higgs Cross Section Working Group Collaboration, “*Handbook of LHC Higgs Cross Sections: 4. Deciphering the Nature of the Higgs Sector*”, doi:10.23731/CYRM-2017-002, arXiv:1610.07922.

[arXiv1902] M. Cepeda et al., “*Higgs Physics at the HL-LHC and HE-LHC*”, technical report, 2019. arXiv:1902.00134.

Geneva, July 26, 2019