Juan M. Cruz-Martinez

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Research Career

University of Milan **Milan (Italy)**
Assegnista di ricerca *2018-currently*
Currently part of the N3PDF research project. PI Stefano Forte. Financed by the European Research Council through an Advanced Grant (n 740006) within the Horizon 2020 Research & Innovation Programme

Durham University **Durham (UK)**
PhD Thesis, Supervisor: Nigel Glover *2014-2018*
Next-to-Next-to-Leading Order QCD Corrections to Higgs Boson Production in Association with two Jets in Vector Boson Fusion. Financed by the Research Executive Agency (REA) of the European Union under the Grant Agreement PITN-GA-2012-316704 ("HiggsTools")

University of Zurich **Zurich (Switzerland)**
Academic Secondment, supervisor: Thomas Gehrmann *Oct-Dec 2016*

IFIC (Valencia) **Valencia (Spain)**
Research Stay, Supervisor: M. Vos *2014*
Project Title: Experimental Limitations to Charge Asymmetry measurement in top quark pair production at hadron colliders

University of Valencia & IFIC **Valencia (Spain)**
Master in Advanced Physics: Theoretical Physics, 94.6% *2013-2014*
Master Thesis supervisor: German Rodrigo
Study of charge asymmetry in $t\bar{t}$ production through axigluons

National Accelerators Center (CNA Sevilla) **Seville (Spain)**
Research Stay, Supervisor: J.M. Lopez-Gutierrez *June 2013*
Project Title: Development of computing tools for the analysis of Accelerator Mass Spectrometry results at the National Accelerators Center

University of Seville **Seville (Spain)**
Degree in Physics, 82.3% *2009-2013*
Bachelor's Thesis supervisor: Antonio Moro
Application of numerical resolution of a system with coupled differential equations to Quantum Scattering Problems with Internal Degrees of Freedom

PhD Thesis

Title: Next-to-Next-to-Leading Order QCD Corrections to Higgs Boson Production in Association with two Jets in Vector Boson Fusion

Supervisors: Nigel Glover (Durham U.) & Thomas Gehrmann (Zurich U.)

Abstract: In this thesis the second-order QCD corrections to electroweak production of a Higgs boson in association with two jets through vector boson fusion are considered. This calculation is fully differential in the kinematics of the Higgs boson and of the final state jets. Infrared divergences are regulated using the antenna subtraction method. We detail the implementation of the process

in the parton-level Monte Carlo integrator NNLOJET and present inclusive calculations as well as differential distributions for a wide range of observables at different center-of-mass energies.

Grant: European Union, PITN-GA-2012-316704. Higgstools Initial Training Network

URL: http://etheses.dur.ac.uk/12806/

Teaching Experience

Teaching Assistant — **University of Milan (Italy)**
Corso di Informatica, 3 years, 108h total — *2019-2022*

Teaching Assistant — **University of Milan (Italy)**
Fisica Quantistica II, 26h — *2020-2021*

Teaching Assistant — **University of Milan (Italy)**
Fisica Quantistica I, 10h — *2019-2020*

NNPDF Code Meeting — **Cambridge (UK)**
Course on the usage of the Keras and Tensorflow libraries, 5h — *June 2019*

Teaching Assistant — **Durham University (UK)**
First Year experimental methods course, weekly exercises, 36 h — *2017-2018*

Student supervision

Co-director of bachelor Thesis — **University of Milan (Italy)**
The effect of discrete dataset on the gluon PDF, D. Chemoli — *2020-2021*

Co-director of master Thesis — **University of Milan (Italy)**
New Monte Carlo Algorithms for Multi-Dimensional Integration with Hardware Acceleration, A. Pasquale — *2020-2021*

Co-director of master Thesis — **University of Milan (Italy)**
Optimized regression models for parton distribution functions determination using deep learning models, N. Lambri — *2019-2020*

Co-director of master Thesis — **University of Milan (Italy)**
Investigating GPU hardware for fast PDF convolutions, E. Villa — *2018-2019*

Co-director of bachelor Thesis — **University of Milan (Italy)**
Stability in the determination of parton distributions, F. Settimo — *2018-2019*

Complementary Education

Cisco Networking Academy — **Remote**
Cisco Cybersecurity Scholarship — *January-June 2021*

Cisco Networking Academy — **Remote**
Introduction to Cybersecurity — *April 2020*

Xilinx Developer Forum — **The Hague (The Netherlands)**
FPGA Developers Forum — *November 2019*

ExotHiggs — **Zuoz (Switzerland)**
Summer School on Higgs and BSM Physics — *August 2016*

YETI — **Durham (UK)**
Winter School: Prospects and Challenges for LHC Run II — *January 2016*

Higgstools Summer School — **Aosta Valley (Italy)**
Summer School on Higgs Physics for Early Stage Researchers — *July 2015*

Higgstools First Young Researches Meeting — **Durham (UK)**
Teamwork, Communication and Media training — *February 2015*

Non-academic work experience

Shell (Projects & Technology Division) — **Rijswijk (The Netherlands)**
Fortran and C Developer — *2016*
Dutch division of the Seismic Applications team (managed by Rob Eppenga).
As part of the Higgstools ITN I was given the opportunity of working at Shell for several months. In Shell I worked on the SIPMAP package, a suite of programs used for oil exploration and seismic tomography. While the formal detail of the algorithms used fall under a completely different branch of physics, the computing side was actually quite close to what it is done in high energy physics research.
My task during this internship consisted on the development and maintenance of the program (the oldest pieces written in Fortran, some of the more modern features C and C++). Runs of this code are very costly and thus optimisation is key, my focus during those months was on improving some of the algorithms and streamlining the workflow of the software. I also worked on porting parts of the code to new hardware (32 bits to 64 bits and GPU accelerators).

FamilyApp — **Seville (Spain)**
Frontend and Backend Developer, Python, HTML — *2014*
Sole developer of both the web interface and administration backend of the service.

Academic Software

MadFlow — **Monte Carlo simulations, GPU computing**
2021, github.com/N3PDF/madflow — *doi:10.5281/zenodo.4954375*
Framework for Monte Carlo simulation of particle physics processes designed to take full advantage of hardware accelerators. Processes can be generated using MadGraph5_aMCNLO and are then output in vectorized (or tensorized) form by the madflow-provided plugin.

VegasFlow — **Numerical calculations, GPU computing**
2020, github.com/N3PDF/vegasflow — *doi:10.1016/j.cpc.2020.107376*
Monte Carlo integration library written in Python and based on the TensorFlow framework. It is developed with a focus on speed and efficiency, enabling researchers to perform very expensive calculation as quick and easy as possible.

Evolutionary-Keras — **Machine Learning, AI, Genetic Algorithms**
2020, github.com/N3PDF/evolutionary_keras — *doi:10.5281/zenodo.3630339*
This module deals with one of the shortcoming of Keras/TensorFlow which is the absence of evolutionary optimizers, implementing several examples to be easily used with TF models.

PDFFlow — **Proton physics, GPU computing**
2020, github.com/N3PDF/pdfflow — *doi:10.1016/j.cpc.2021.107995*
Parton distribution function interpolation library written in Python and based on the TensorFlow framework. It is developed with a focus on speed and efficiency, enabling researchers to perform very expensive calculation as quick and easy as possible.

pyHepGrid — **Python, grid computing**
2016, github.com/scarlehoff/pyHepGrid — *doi:10.5281/zenodo.3233861*

Core developer of the pyHepGrid tool for distributed computing. Used to run in a systematic and coherent manner resource-hungry programs typically used for HEP simulations. The development of pyHepGrid was done with the focus on NNLOJET but has since being extended successfully to also run other programs such as MCFM, Sherpa or HEJ.

Relevant computer skills

Programming Languages: Fortran, Python, C, C++, js, OpenCL, Cuda

Operating System: Linux, MacOS, Windows

Scripting/Macro Languages: Bash, Latex, gnuplot

Computing Tools: Maple, Mathematica, Matlab, Grid Computing

ML Libraries: Keras, Tensorflow, PyTorch, pandas, scipy

Technologies: Grid Computing, multiprocessing, FPGA computing, GPU computing

Other Projects

pybliotecario — **Python, social bot**
github.com/scarlehoff/pybliotecario — *Currently*
Bot in python that use different remote APIs such as Facebook Messenger API or Telegram to open a communication channel between the social messaging system of choice and the server.

Open Source — **Open source contributor**
github.com/scarlehoff — *Currently*
I often contribute in different open source projects and am currently the maintainer of several packages in the Arch User Repository

Participation in grants

Automate Monte Carlo simulation on hardware accelerators — **University of Milan (Italy)**
Linea 2A, 15000€ (4 Co-Authors) — *2020-2021*

New hardware for HEP — **University of Milan (Italy)**
Linea 2A, 6000€ (3 Co-Authors) — *2019-2020*

Management Experience

HiggsTools Final Meeting — **Durham (UK)**
Member of the organising Committee — *September 2017*

Annual YTF (Young Theorist Forum) 8, 9, 10 — **Durham (UK)**
Member of the organising Committee — *2016-2018*

ICHEP 2014 — **Valencia (Spain)**
Outreach activities — *July 2014*

Awards

Profesor Ayudante Doctor: "Lecturer" level recognized by the Spanish National Agency for Quality Assessment and Accreditation (ANECA)

Highest Distinction: Bachelor's Thesis: Numerical resolution of a system with coupled differential equations: applied to Quantum Scattering Problems with Internal Degrees of Freedom

Third Prize: "IV Concurso Nacional para promocion de Jovenes Escritores Cientifico-Tecnicos" ACTA-CEDRO, Scientific Writing

First Prize: "I Concurso Narrativa Juvenil de la Comarca de La Vega"
Asociación Gran Vega de Sevilla, Creative Writing

Languages

Spanish: Native
English: Fluent — *PhD studies carried out in Durham (United Kingdom)*
Italian: Fluent — *University level courses taught and students supervised in Italian*
French: Basic knowledge — *6 years at high school*
Japanese: Basic knowledge — *A1.2 level certified*

Conference Talks and Invited Seminars

The 2021 International Workshop on the High Energy Circular Electron Positron Collider — **Nanjing (China, Virtual)**
GPU acceleration in High Energy Physics — *November 2021*

Invited Seminar (virtual) — **KIT Karlsruhe (Germany)**
Towards a GPU future for particle physics Monte Carlo simulations — *June 2021*

25th International Conference on Computing in High-Energy and Nuclear Physics (vCHEP) — **Virtual**
MadFlow: towards the automation of Monte Carlo simulation on GPU for particle physics — *May 2021*

PDF4LHC 2021 — **Virtual**
New studies from the NNPDF group — *March 2021*

Milano Joint Phenomenology Seminar — **Milan (Italy, Virtual)**
Offloading Monte Carlo simulations to hardware accelerators — *February 2021*

Invited Seminar (virtual) — **IFIC Valencia (Spain)**
PDF determination with a quantum hardware — *February 2021*

HSF WLCG Virtual Workshop — **Virtual meeting**
PDF/Vegas-Flow — *November 2020*

Generator Infrastructure and Tools Subgroup Meeting — **CERN (Virtual meeting)**
VegasFlow and PDFFlow: accelerating Monte Carlo simulation across multiple devices (joint talk with M. Rossi) — *October 2020*

40th International Conference on High Energy Physics, ICHEP — **Prague (Virtual meeting)**
VegasFlow: accelerating Monte Carlo simulation across platforms — *August 2020*

NNPDF Collaboration meeting — **Amsterdam (The Netherlands)**
Optimizing the hyperoptimization — *February 2020*

Artificial Intelligence for Science, Industry and Society Symposium (AISIS 2019) — **Ciudad de Mexico (Mexico)**
Studying the parton content of the proton with deep learning models — *October 2019*

James Stirling Memorial Conference & PDF4LHC — **Durham (UK)**
Methodological improvements in PDF determination — *September 2019*

NNPDF Collaboration meeting — **Varenna (Italy)**
n3fit and hyperoptimization in the context of NNPDF 4.0 — *August 2019*

QCD@LHC 2019 — **Buffalo, New York (USA)**
Towards a new generation of PDFs with deep learning models — *July 2019*

NNLOJET Collaboration meeting — **Zurich (Switzerland)**
Numerical Integration with Neural Networks — *May 2019*

NNPDF Collaboration meeting — **Amsterdam (The Netherlands)**
N3PDF studies of new methodologies — *February 2019*

NNPDF Collaboration & N3PDF Kickoff Meeting — **Gargnano, Lake Garda (Italy)**
Recent developments within NNLOJET — *September 2018*

Loops and Legs in Quantum Field Theory 2018 — **St. Goar (Germany)**
NNLO corrections to VBF Higgs boson production — *May 2018*

HiggsTools Final Meeting — **Durham (UK)**
NNLO phenomenology with Antenna Subtraction — *September 2017*

Internal Seminar — **Durham (UK)**
ϕ^*_η *observable for Higgs production* — *May 2017*

Student Seminar — **Durham (UK)**
Higgs phenomenology with antenna subtraction — *February 2017*

Invited Seminar — **Valencia (Spain)**
Higgs phenomenology with antenna subtraction — *January 2017*

HiggsTools Second Annual Meeting — **Granada (Spain)**
NNLO calculations for Higgs processes — *April 2016*

Internal Seminar — **Durham (UK)**
Renormalisation Scale Dependence as a Testing Ground for NNLO calculations — *February 2016*

Student Seminar — **Durham (UK)**
Building and Playing with NNLO Monte Carlos — *February 2016*

HiggsTools First Annual Meeting — **Freiburg (Germany)**
NNLO predictions for Higgs production at LHC — *April 2015*

Publications

[1] NNPDF Collaboration. "An open-source machine learning framework for global analyses of parton distributions". In: *Eur. Phys. J. C* 81 (Sept. 2021), p. 958. DOI: 10.1140/epjc/s10052-021-09747-9. arXiv: 2109.02671 [hep-ph].

[2] Stefano Carrazza et al. "MadFlow: automating Monte Carlo simulation on GPU for particle physics processes". In: *Eur. Phys. J. C* 81.7 (2021), p. 656. DOI: 10.1140/epjc/s10052-021-09443-8. arXiv: 2106.10279 [physics.comp-ph].

[3] Stefano Carrazza, Juan M. Cruz-Martinez, and Tanjona R. Rabemananjara. "Compressing PDF sets using generative adversarial networks". In: *Eur. Phys. J. C* 81.6 (2021), p. 530. DOI: 10.1140/epjc/s10052-021-09338-8. arXiv: 2104.04535 [hep-ph].

[4] Adrian Perez-Salinas et al. "Determining the proton content with a quantum computer". In: *Phys. Rev. D* 103 (2021), p. 034027. DOI: 10.1103/PhysRevD.103.034027. arXiv: 2011.13934 [hep-ph].

[5] Stefano Carrazza, Juan M. Cruz-Martinez, and Marco Rossi. "PDFFlow: Parton distribution functions on GPU". In: *Computer Physics Communications* 264 (2021), p. 107995. ISSN: 0010-4655. DOI: https://doi.org/10.1016/j.cpc.2021.107995. arXiv: 2009.06635 [hep-ph]. URL: https://www.sciencedirect.com/science/article/pii/S0010465521001077.

[6] Stefano Carrazza and Juan M. Cruz-Martinez. "VegasFlow: accelerating Monte Carlo simulation across multiple hardware platforms". In: *Comput. Phys. Commun.* 254 (2020), p. 107376. DOI: 10.1016/j.cpc.2020.107376. arXiv: 2002.12921 [physics.comp-ph].

[7] Stefano Carrazza and Juan Cruz-Martinez. "Towards a new generation of parton densities with deep learning models". In: *Eur. Phys. J.* C79.8 (2019), p. 676. DOI: 10.1140/epjc/s10052-019-7197-2. arXiv: 1907.05075 [hep-ph].

[8] J. Cruz-Martinez et al. "Second-order QCD effects in Higgs boson production through vector boson fusion". In: *Phys. Lett.* B781 (2018), pp. 672–677. DOI: 10.1016/j.physletb.2018.04.046. arXiv: 1802.02445 [hep-ph].

[9] M. Boggia et al. "The HiggsTools handbook: a beginners guide to decoding the Higgs sector". In: *J. Phys.* G45.6 (2018), p. 065004. DOI: 10.1088/1361-6471/aab812. arXiv: 1711.09875 [hep-ph].

[10] X. Chen et al. "NNLO QCD corrections to Higgs boson production at large transverse momentum". In: *JHEP* 10 (2016), p. 066. DOI: 10.1007/JHEP10(2016)066. arXiv: 1607.08817 [hep-ph].

In review process

[1] A. Buckley et al. "A comparative study of Higgs boson production from vector-boson fusion". In: (May 2021). arXiv: 2105.11399 [hep-ph].

[2] Richard D. Ball et al. "The Path to Proton Structure at One-Percent Accuracy". In: (Sept. 2021). arXiv: 2109.02653 [hep-ph].

[3] Stefano Carrazza, Juan M. Cruz-Martinez, and Roy Stegeman. "A data-based parametrization of parton distribution functions". In: (Nov. 2021). arXiv: 2111.02954 [hep-ph].

Community Papers

[1] P. Azzi et al. "Report from Working Group 1". In: *CERN Yellow Rep. Monogr.* 7 (2019), pp. 1–220. DOI: 10.23731/CYRM-2019-007.1. arXiv: 1902.04070 [hep-ph].

[2] S. Amoroso et al. "Les Houches 2019: Physics at TeV Colliders: Standard Model Working Group Report". In: *11th Les Houches Workshop on Physics at TeV Colliders: PhysTeV Les Houches*. Mar. 2020. arXiv: 2003.01700 [hep-ph]. URL: http://cds.cern.ch/record/2712776.

PhD Thesis

[1] Juan M Cruz-Martinez. "Next-to-Next-to-Leading Order QCD Corrections to Higgs Boson Production in Association with two Jets in Vector Boson Fusion". PhD thesis. Durham U. (main), 2018. URL: http://etheses.dur.ac.uk/12806/.

Conference proceedings

[1] Stefano Carrazza et al. "Towards the automation of Monte Carlo simulation on GPU for particle physics processes". In: *25th International Conference on Computing in High-Energy and Nuclear Physics*. May 2021. arXiv: 2105.10529 [physics.comp-ph].

[2] Juan Cruz-Martinez, Stefano Forte, and Emanuele R. Nocera. "Future tests of parton distributions". In: *Acta Phys. Polon. B* 52 (2021), p. 243. DOI: 10.5506/APhysPolB.52.243. arXiv: 2103.08606 [hep-ph].

[3] Marco Rossi, Stefano Carrazza, and Juan M. Cruz-Martinez. "PDFFlow: hardware accelerating parton density access". In: *40th International Conference on High Energy Physics*. Dec. 2020. DOI: 10.5821/zenodo.4286175. arXiv: 2012.08221 [hep-ph]. URL: https://pos.sissa.it/390/921/.

[4] Stefano Carrazza and Juan M. Cruz-Martinez. "VegasFlow: accelerating Monte Carlo simulation across platforms". In: *40th International Conference on High Energy Physics*. Oct. 2020. arXiv: 2010.09341 [physics.comp-ph]. URL: https://pos.sissa.it/390/906/.

[5] Stefano Carrazza, Juan M. Cruz-Martinez, and Christopher Schwan. "Constructing PineAPPL grids on hardware accelerators". In: *PoS* LHCP2020 (2021). Ed. by Bruno Mansoulie et al., p. 057. DOI: 10.22323/1.382.0057. arXiv: 2009.11798 [hep-ph].

[6] Juan M. Cruz-Martinez, Stefano Carrazza, and Roy Stegeman. "Studying the parton content of the proton with deep learning models". In: *Artificial Intelligence for Science, Industry and Society*. Feb. 2020. DOI: 10.22323/1.372.0008. arXiv: 2002.06587 [physics.comp-ph].

[7] Stefano Carrazza et al. "Towards hardware acceleration for parton densities estimation". In: *Frascati Phys. Ser.* 69 (2019), pp. 1–6. arXiv: 1909.10547 [hep-ph]. URL: http://library.lnf.infn.it/volumi-pubblicati/.

[8] Juan Cruz-Martinez et al. "NNLO corrections to VBF Higgs boson production". In: *PoS* LL2018 (2018), p. 003. DOI: 10.22323/1.303.0003. arXiv: 1807.07908 [hep-ph].

[9] J. Cruz-Martinez. "Higgs Production at NNLO in VBF". In: *Acta Phys. Polon. Supp.* 11 (2018), pp. 277–284. DOI: 10.5506/APhysPolBSupp.11.277.

[10] Thomas Gehrmann et al. "Jet cross sections and transverse momentum distributions with NNLOJET". In: *PoS* RADCOR2017 (2018), p. 074. DOI: 10.22323/1.290.0074. arXiv: 1801.06415 [hep-ph].

Open acess academic software

[1] Richard D. Ball et al. *NNPDF/nnpdf: An open-source machine learning framework for global analyses of parton distributions*. Version 4.0. Sept. 2021. DOI: 10.5281/zenodo.5362228. URL: https://doi.org/10.5281/zenodo.5362228.

[2] Juan M. Cruz-Martinez et al. *N3PDF/madflow: Automating event generation MC simulation on hardware accelerators.* Version v0.9. June 2021. DOI: 10.5281/zenodo.4954375. URL: https://doi.org/10.5281/zenodo.4954375.

[3] Tanjona Rabemananjara, Juan Cruz-Martinez, and Stefano Carrazza. *N3PDF/pycompressor: PDF (parton distribution functions) compression framework*. Version v1.1.0. Mar. 2021. DOI: 10.5281/zenodo.4616385. URL: https://doi.org/10.5281/zenodo.4616385.

[4] Juan M. Cruz-Martinez and Stefano Carrazza. *N3PDF/vegasflow: Accelerating Monte Carlo integrations across multiple hardware platforms*. Version v.1.0. Mar. 2020. DOI: 10.5281/zenodo.3691926.. URL: https://doi.org/10.5281/zenodo.3691926.

[5] Juan Cruz-Martinez, Marco Rossi, and Stefano Carrazza. *N3PDF/pdfflow: Fast device agnostic Parton Distribution Function interpolation*. Version v1.0. Sept. 2020. DOI: 10.5281/zenodo.3964190. URL: https://doi.org/10.5281/zenodo.3964190.

[6] Felix Hekhorn et al. *N3PDF/eko: Solves the DGLAP equations in Mellin space and produces evolution kernel operators (EKO)*. Version 0.1.2-20.06. June 2020. DOI: 10.5281/zenodo.3874237. URL: https://doi.org/10.5281/zenodo.3874237.

[7] Juan M. Cruz-Martinez, Roy Stegeman, and Stefano Carrazza. *N3PDF/evolutionary_keras: An evolutionary algorithm implementation for Keras*. Version v.1.0.1. Feb. 2020. DOI: 10.5281/zenodo.3630339. URL: https://doi.org/10.5281/zenodo.3630339.

[8] Juan Cruz-Martinez, Duncan Walker, and James Whitehead. *pyHepGrid: Distributed computing made easy*. Version 0.9. May 2019. DOI: 10.5281/zenodo.3233862. URL: https://doi.org/10.5281/zenodo.3233862.