Brunella D'Anzi - Curriculum Vitae

Personal Information

Date of birth: 03/03/1997 — Age 25
Place of birth: Matera (MT), Italy
Nationality: Italian
Pronouns (Gender): She, her, hers (Female)
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Institutes: University *Aldo Moro* and INFN Bari

University of Bari (*3 Nov 2021–Present*)
Position (EQF Level 8): Doctor of Philosophy (Ph.D.) in Experimental Particle Physics
Research project: Deep Learning techniques for track reconstruction and search for non-resonant production of double Higgs bosons decaying into muon pairs and two b-jets in pp collisions with the CMS experiment at the LHC
Advisor: Prof. Nicola De Filippis (Polytechnic and INFN Bari)
Attended Courses: C++, Geant4, Effective field theories and Physics Beyond the Standard Model, Advanced Machine Learning, Trigger and DAQ for Particle physics, Big Data modeling and learning, Physics signal treatments, Making a Brief Technical Presentation in English
Summary: Starting from the knowledge acquired for my Master's thesis project in performing double Higgs searches, the aim of my Ph.D. is the never-done-before investigation of a new intriguing channel, having an Higgs boson with a clean signature represented by two muons and the other Higgs boson having the highest branching ratio decay mode in two b-jets. The evidence of the Higgs boson in two muons in the CMS experiment pushed the interest of the Higgs experts towards this direction. Moreover, it represents a great opportunity to update the data analsysis strategy to the usage of lightest data formats for the samples, Deep Learning techniques both for the b-tagging and CMS track reconstruction, the computation of scale factors using the tools developed in my first year CMS qualification task for the tracking efficiency measurements. The CMS Run 2 analysis at $\sqrt{s}$ = 13 TeV using simulation is the starting point for the most promising Run 3 and HL-LHC analyses.

Music Conservatory Niccolò Piccinni of Bari (*2016–21st March 2022*)
Position (L-30): Bachelor of Science (B.Sc.) in Violin
Dissertation's title (Italian language): Comparison between the genius of the physicist Albert Einstein and the genius of the musician Ludwig Van Beethoven
Grade: 110/110 with honors [Transcripts]
Advisor: Prof. Carmelo Andriani (Music Conservatory of Bari)

University of Bari (*2019–26th October 2021*)
Position (LM-17): Master of Science (M.Sc.) in Nuclear, Subnuclear and Astroparticle Physics
Dissertation's title (English language): Search for double Higgs events produced via a vector boson fusion mechanism in the decay channel $b\bar{b}4l$ with the CMS experiment at the LHC.

Grade: 110/110 with honors [Diploma Supplement]
Advisor: Prof. Nicola De Filippis (Polytechnic and INFN Bari)
Summary: The Higgs boson discovery at the Large Hadron Collider (LHC) in 2012 led to a new era of High Energy Physics studies in the scalar sector and to the search for new physics signals beyond the Particle Physics standard model. Also, after the precision measurements of the main parameters of the Higgs boson including its mass, one of the main objectives of research is the measure of the couplings of the Higgs with itself, strictly linked to the shape of the scalar potential describing the Brout-Englert-Higgs mechanism. In particular, the studies of the trilinear self-coupling of the Higgs boson λ_{HHH} and the coupling of a pair of Higgs with a pair of gauge bosons (λ_{VVHH}, with V = $W^{\pm}$, Z) involve processes with production of a pair of Higgs bosons. The double Higgs production process via gluon-gluon fusion is the main mode of production of double Higgs at the Run 2 collision energies of LHC, useful for setting constraints on the value of λ_{HHH}, while the vector boson fusion mechanism provides the only means of access to the VVHH coupling. Therefore, the thesis in question aimed to search for double Higgs boson (HH) non-resonant production events through the fusion mechanism of vector bosons (VBF), when the two Higgs bosons decay in two b-jets (the highest branching ratio for the Higgs boson production at LHC) and $ZZ \rightarrow 4$ charged leptons (benefit from a clean signature), respectively, and are accompanied by two very energetic forward jets; for this purpose, we perfomed the analysis using Monte Carlo samples scaled to data collected during the 2018 data-taking campaign of Run 2 of the Compact Muon Solenoid (CMS) experiment at Large Hadron Collider (LHC). The tricky task of the research was related to the small cross section that characterizes the VBF HH process, the second highest for LHC energies, after the mode of gluon-gluon fusion production (ggHH). Indeed, the production rate of 1.723 fb is about 15 times smaller than ggHH. Moreover, the branching ratio is 2.79×10^{-4} for $H \rightarrow ZZ \rightarrow 4l$, with $l = e, \mu$. The presence of anomalies in the self-couplings of the Higgs due to the contributions of new physics leads to an increase in the production rate of signal. Therefore, the strategy adopted was the detailed study of the characteristics of events at a few points in the coupling parameter space and then generalize the analysis. We used multivariate analysis techniques of machine learning to improve signal sensitivity above background being dominated by single Higgs production in fusion topology vector bosons and from double Higgs via gluon-gluon fusion. To be more specific, we implemented and optimized a Deep Neural Network for the discrimination of the signal from the background events to be used to obtain a physics result in terms of upper limit on the cross section of the process.

University of Bari (*2016–30th September 2019*)
Position (L-30): Bachelor of Science (B.Sc.) in Physics, 2019
Dissertation's title (Italian language): Two quantum-states systems
Grade: 110/110 with honors [Diploma Supplement]
Advisor: Prof. Leonardo Angelini (University and INFN Bari)

Esperienza Professionale

Official CERN Guide (*April 2023–Present*).
I am a volunteer as a CERN Guide for Visitor Tours in many CERN areas such as the CERN Science Gateway Labs, Exhibitions and Science Shows.

Technical Shifter and Shift Leader for the CMS experiment (*April 2023–Present*).
During CMS Run 3 data taking, I am a shifter to monitor the High Voltage CMS sub-detectors and security system (underground and surface) as a Technical Shifter and lead the daily data taking program as a Shift Leader.

Tutor for the *Drift Tube Characterization hands-on exercise* in the *2023 EURIZON Detector School* (*17–28 July 2023*).
The EURIZON Detector School is organized for training young scientists on state-of-the-art particle detection technologies in the fields of particle-, heavy-ion- and neutron-physics. The main program of the school comprises morning lectures by world experts in their fields, and hands-on exercises on various technologies in the afternoons.

CERN Supervisor for the Non-Member State CERN Summer Student Eliacim Velez (*July–August 2023*).
Summer Student Supervisor under my research project *Search for double Higgs events in muon pairs and b-jets with the CMS experiment*.

Fourth Machine Learning INFN Hackathon. (*21–23 June 2023*).
Tutor for 6 INFN members/associates in the Fourth Machine Learning INFN hackathon proposing Higgs searches at the LHC as a Jupyter Notebook exercise running at the CNAF Tier 1 using simulated samples scaled to the Run 2 CMS integrated luminosities.

Facilitator for the *Tracking and Vertexing Short Exercise* in the *CERN CMS Data Analysis School 2023* (*5–10 June 2023*).
CERN CMS Data Analysis School is the first opportunity for European MSc. and PhD students to get familiar with the CMSSW framework to perform data analysis and go for the publication procedure within the CMS Collaboration.

Chair of two sessions in the *Large Hadron Collider (LHC) Job Matching Event Spring '23 Moderator*. (*3 May 2023*).
The JMEv is organized by a team of volunteers, members of the LHC Early Career Scientists Fora, which comprises the ALICE Junior Representatives, ATLAS Early Career Scientist Board, CMS Young Scientists Committee and the LHCb Early Career, Gender and Diversity Office.

Tutor for the *Programming workshop: Build your first website with the help of CERN coaches* in the *Django Girls Geneva Event* (*21–22 April 2023*).
The Django Girls workshop offers a crash course in computer programming for beginners aged 15 and over. The aim is to introduce digital technologies to the uninitiated, especially women, who are underrepresented in this field.

Education Volunteer for Save The Children Italia (*February 2023–Present*).
The Volunteers for Education project aims to recover the motivation to study of children and adolescents, aged 9 to 17, affected by the educational crisis produced by the Covid-19 pandemic.

Supervisor for the MSc. HEP Thesis by Michele Barbieri (*January 2023–April 2023*).

Master's Degree Supervisor for the thesis under my research project *Search for double Higgs events in muon pairs and b-jets with the CMS experiment*.

Lead Contact Facilitator for the *Tracking and Vertexing Short Exercise* and Facilitator for the *Short Muon Short Exercise* in the *Fermilab CMS Data Analysis School 2023* (*9 Jan 2023–15 Jan 2023*).
Fermilab CMS Data Analysis School is the first opportunity for American MSc. and PhD students to get familiar with the CMSSW framework to perform data analysis and go for the publication procedure within the CMS Collaboration.

INFN Local Team responsible for the outreach path *L'Intelligenza Artificiale incontra la Fisica* in the *INFN Scienza per Tutti* project (*Sep 2022–Present*).
Scienza Per Tutti is the scientific communication site of the National Institute of Nuclear Physics. The INFN research community collaborates in this communication project to make all topics of science, in particular physics, and technology accessible. In the section Percorsi Divulgativi a new outreach section will be added soon about the above-cited topic.

Data Quality Monitoring (DQM) Online shifter for the CMS experiment (*April 2022–June 2022*).
To have a better overview of the CMS experiment sub-detector components, I have been the "CMS eyes" for 20 shifts as the only trained person looking at each CMS sub-detectors physics quantities summary plots along with Detector-On-Call experts.

Qualification task for the CMS Collaboration: Tracking efficiency performance results using the data-driven Tag and Probe technique (*April 2022–June 2022*).
A new framework has been developed to speed up the computation using Apache Spark, and, in Early Run 3 data, misalignment and miscalibration effects has been spotted in high η muon regions.

Tutor Didattico e Assistente in *Fisica Applicata con laboratorio*, Università di Bari. (*Mar 2021–Presente*)
Argomenti: Meccanica Classica, Termodinamica ed Elettromagnetismo per Studenti Triennali di Biotecnologie all'Università di Bari.

Part of the INFN Local Team in the INFN outreach *What Next? Giovani che raccontano il futuro* project (*Feb 2021–Present*).
A short film of the one-day experience with High-School and University students has been made public from the 5th October 2022.

Seconda Edizione dell'Hackathon di Machine Learning dell'INFN. (*13–15 Dicembre 2021*)
Tutor nell'Hackathon di Machine Learning promosso dall'INFN per sei membri/associati INFN alla ricerca del bosone di Higgs con campioni di segnale/fondo simulati e scalati alla luminosità integrata di Run II di CMS.

Borse di studio e Premi

Invito a contribuire agli articoli collaborativi di LinkedIn Machine Learning, Statistica e Ricerca **(*August 2023–Present*)**
Selezione per la partecipazione al 13esimo CMS Patatrack Hackathon al CERN **(*July 2023*)**
Selezione come uno dei due dottorandi del CERN per il programma Innovation 4 Change promosso da CDI and CERN Ideasquare (Commisione composta da Fabiola Giannotti, John Elkan, Francesco Profumo e altri Leader dell'Innovazione) **(*1st Febrary 2023–4 July 2023*)**
INFN CERN Doctoral Student Semi-Fellowship **(*1st March 2023–Present*)**
Invito ad apparire sul numero 100esimo della rivista Suonare News Magazine in rappresentanza del Conseratorio di Musica Niccolò Piccinni **(*February 2023*)**
2022 CMS Data Analysis School 3rd Prize Team **(*4th–15th January 2022*)**
Best Poster Awards ACAT 2021 **(*29th November 2021–3rd December 2021*)**
University of Bari 3-years Ph.D. Scholarship and INFN Associate **(*3rd Nov 2021–Present*)**
CSN1 INFN 3-months Scholarship at International Laboratories (CERN) for 12 best High Energy Physics students Call n.21706/2019 **(*26th July 2021–3rd November 2021*)**
Winner of two monthly competition "Scienza per tutti" organized by INFN **(*14th December 2017–14th September 2021*)**
Private ECOMAP facility Scholarships for best Italian students **(*2016–2022*)**
University of Bari Book Scholarships for its best 300 students **(*2016–2020*)**

Esperienze di Ricerca

Fisica delle Alte Energie, Machine learning/Higgs tagging. Sviluppo di una Rete Neurale per l'identificazione di bosoni Higgs che decadono in due muoni e 2 b-jets (due bosoni Z e quattro leptoni carichi (4mu,4e,2e2mu)) nell'esperimento CMS (*2021–Presente*).

Efficienza HEP/Efficienza di tracciamenti dei Muoni con tecnica di Tag and Probe. Misurazione dell'efficienza di tracciamento Muon nell'esperimento CMS utilizzando il metodo Tag and Probe **(*Marzo 2022–Presente*)**

Rivelatori Gassosi/Assemblaggio e Test del rivelatore *Fast timing Micropattern gaseous detector (FTM).* L'attuale generazione di rivelatori gassosi a Micro Pattern (MPGD) è resistente alle radiazioni, con una rate capability di diversi MHz/cm^2, una buona risoluzione spaziale ($\leq 50\mu m$) e una risoluzione temporale di 5-10 ns, che soddisferà le esigenze degli attuali esperimenti e i loro upgrade (CMS & ATLAS) ma non è sufficiente per l'identificazione dei vertici e del bunch crossing ai futuri collisionatori e ridurre il pile-up da O(1000) a livelli gestibili di O(25) **(*Luglio 2021–Ottobre 2021*)**

Rivelatori Gassosi/Camera a deriva IDEA IDEA (Innovative Detector for an Electron-positron Accelerator) è un concetto innovativo di rivelatore generico, progettato per studiare le collisioni elettrone-positrone in un ampio intervallo di energia fornito da un collisore leptonico circolare molto grande. La camera di deriva IDEA è progettata per fornire un tracciamento efficiente, una misurazione della quantità di moto di alta precisione e un'eccellente identificazione delle particelle sfruttando l'applicazione della tecnica del conteggio dei cluster. Per studiare il potenziale delle tecniche di conteggio dei cluster su eventi di fisica, sono in corso studi di simulazione e

l'acquisizione di dati di Test Beam **(*Gennaio 2022–Presente*)**

Machine learning/Corsi e Scuole. *"Machine Learning", Stanford University* – *"Addressing LHC Challenges by Machine Learning", HSE University* – *2nd Terascale School of Machine Learning , DESY* **(*2021–Present*)**

Fisica delle Alte Energie/Corsi, Scuole e Hackathon. *13th CMS Patatrack Hackathon* – *FCC Software Hands-on Tutorial 2022* – *CMS Data Analysis School (CMSDAS) 2022* – *Virtual Monte Carlo School – PB TMDs with CASCADE* – CERN Webfest annual hackathon 2021 – *ESCAPE Summer School on Data Science for Astronomy, Astroparticle and Particle Physics , Laboratoire d'Annecy de Physique des Particules, Annecy, France* – *SHINE Autumn School: Detectors and Data Processing , CERN* – *SHINE Autumn School: Physics and Facility , CERN* – *Terascale Virtual Summer School 2020, DESY* – *Online Reduced Terascale Statistics School 2020 , PHYSTAT* – *"Particle Physics:an introduction", Geneva University* – *"Terascale Summer School: QCD and Monte Carlo techniques", DESY* **(*2021–Present*)**

Linguaggi di Programmazione/Corsi e Scuole. *"Data Week April 2023"* – *"Edition IV Boolean Coding Week 2023" "Edition III Boolean Coding Week 2022"* – *"Programming Foundations with JavaScript, HTML and CSS",Duke University* – *"Learning Cloud Computing: Core Concepts"* – *"Learning LabVIEW"* – *"Python Data Analysis"* – *"Python:Programming Efficiently"* – *"Artificial Intelligence Concepts"* – *"HTML course"* – *"Java course"* – *"SQL course"* – *"MATLAB: Fundamentals"* **(*2021–Present*)**.

Competenze Trasversali/Corsi. *CERN Safety and Experimental Training Courses* – *"Certified Peer Reviewer Course", Elsevier* – "Becoming a peer reviewer", Elsevier – *Public speaking and scientific writing* – *"Technical Writing", Moscow Institute of Physics and Technology*, *"Introduction to Overleaf", CERN* – *"Professional Skills: Interpersonal Skills"* – *"Professional Skills: Solving Problems with Critical and Creative Talking"* **(*2021–Present*)**.

Pubblicazioni, Relazioni, Capitoli di libri e Atti di Conferenze

As an active member of a large Collaboration like the CMS one, I am a CMS Author of every physics paper since 8th November 2022. Selected publications, notes, and conference proceedings to which I gave a substantial contribution are listed below.

[1] M. I. Abdulhamid et al., "Azimuthal correlations of high transverse momentum jets at next-to-leading order in the parton branching method", Eur. Phys. J. C **82**, 36 (2022), doi:10.1140/epjc/s10052-022-09997-1, arXiv:2112.10465.

Presentazioni a Conferenze, Workshop e Seminari

Fourth Edition Machine Learning INFN hackathon - Starting level, Plenary session (*23rd June 2023*)
Discriminazione Segnale/Fondo per il canale di produzione del bosone Higgs nel canale 4 leptoni con l'esperimento CMS usando tecniche di Machine Learning di classificazione

CERN CMS Data Analysis School (2023), Short Exercise Session (*5th June 2023*)
CMS Tracking and Vertexing

IAS Program on High Energy Physics (HEP 2023), Talk in Mini-Workshops in Theory and Experiment and Detector (*13th February 2023*)
IDEA Drift Chamber

CMS Data Analysis School (2023), Talk in Short Exercise Session (*9th January 2023*)
CMS Tracking and Vertexing

21st Workshop Internazionale su Advanced Computing and Analysis Techniques in Physics Research (ACAT2022), Poster (*27th October 2022*)
Cluster counting algorithms for particle identification at future colliders

2022 Workshop Internazionale su the high energy Circular Electron-Positron Collider (CEPC2022), Talk in Gaseous Detectors Parallel session (*26th October 2022*)
Beam test results on cluster counting

21st International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT2022), Poster (*24th October 2022*)
CMS tracking performance in Run 2 and early Run 3 data using the tag-and-probe technique

INFN Workshop for Future Detectors (IFD2022), Talk in Plenary session (*18th October 2022*)
The IDEA drift chamber at FCC-ee and CEPC and related Electronics

CMS Physics Performance and Dataset (PPD) General Meeting, Approval Talk
Detector Performance note approval: CMS tracking performance in Run 2 and early Run 3 data using the tag-and-probe technique

CMS General Meeting Tracker and Tracking Detector Performance Groups (DPG), Pre-approval Talk (*28th September 2022*)
Pre-approval for Muon tracking performance in the CMS Early-Run 3 data using the tag and probe technique

108th National Congress of the Società Italiana di Fisica (SIF2022), Talk in HEP Parallel session (*13th September 2022*)
CMS tracking performance in the early Run 3 data using the tagand-probe technique on behalf of the CMS Collaboration

15th Pisa Meeting on Advanced Detectors Edition 2022, Poster session (*27 maggio 2022*)
Identificazione delle particelle con la tecnica di conteggio dei cluster per la camera di deriva IDEA

Higgs al CMS Italia Workshop, Talk (*12 maggio 2022*)
Analisi di doppio Higgs in bbmumu

Imparare a scoprire conferenza, conversazione (*28 aprile 2022*)
Alla ricerca di rari eventi di-Higgs all'LHC con tecniche di Machine (Deep) Learning

Muon Tracking POG Meeting, Talk (*11 aprile 2022*)
Aggiornamento dell'algoritmo di efficienza Muon tramite tecniche Tag e Probe

Incontro tra l"INFN, IHEP e Jilin University, Talk (*17 marzo 2022*)
Discussione sull'algoritmo di conteggio dei cluster e i risultati dell'analisi del test del fascio.

Incontro tra l'INFN, IHEP e Jilin University, Talk (*18 febbraio 2022*)
Discussione sull'algoritmo di conteggio dei cluster e i risultati dell'analisi del test del fascio.

Secondo hackathon ML_INFN - Livello iniziale, sessioni di tutoraggio e presentazione di casi d'uso (*15 dicembre 2021*)
Discriminazione segnale/sfondo per il canale di decadimento dei quattro leptoni VBF Higgs con l'esperimento CMS utilizzando tecniche di classificazione Machine Learning

2021 ACAT Workshop, sessione di Lightning talk per Posters Awards (*3 dicembre 2021*)
Discriminazione di segnale da fondo per la produzione di eventi di doppio bosone di Higgs tramite il meccanismo di fusione del bosone vettoriale nel canale di decadimento con quattro leptoni carichi e due b-jet nello stato finale dell'esperimento LHC.

Università degli Studi di Bari, Seminario per studenti di Laurea Magistrale in Fisica (*15 marzo 2021*)
"Seminario "The Top Quark discovery at the Fermilab Tevatron collider"

Date **Signature**

September 9, 2023

Altre Pubblicazioni

Tutte le altre pubblicazioni sono elencate di seguito.

[1] M. I. Abdulhamid et al., "Azimuthal correlations of high transverse momentum jets at next-to-leading order in the parton branching method", Eur. Phys. J. C **82**, 36 (2022), doi:10.1140/epjc/s10052-022-09997-1, arXiv:2112.10465.