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Broj: 939

Datum: 06.05.2022.god

UNIVERZITET CRNE GORE

SENATU

CENTAR ZA DOKTORSKE STUDIJE

U prilogu akta dostavljam Odluke sa LXXXI sjednice Vijeća Prirodno-matematičkog fakuteta održane 05.05.2022. godine.

UNIVERZITET CRNE GORE Prirodno-matematički fakultet

D e k a n,

Prof. dr Predrag Miranović

Univerzitet Crne Gore
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Datum: 06.05.2022. god

Na osnovu člana 64 stav 2 tačka 8 Statuta, a u vezi sa članom 43 i 44 Pravila doktorskih studija Univerziteta Crne Gore, shodno članu 9.3. Sporazuma o dvojnom doktoratu između Univerziteta Crne Gore i Univerziteta Paris Saclay, Vijeće Prirodno-matematičkog fakulteta na LXXXI sjednici održanoj dana 05.05.2022. godine, donijelo je

ODLUKU

I

Prihvata se Izvještaj komisije za ocjenu doktorske disertacije pod nazivom *"Mjerenje N-džetnosti varijabli u događajima sa produkcijom Z bozona u SMS detektoru i performance njegovog elektromagnetnog kalorimetra"* kandidata Jelene Mijušković.

II

Predlažemo Senatu Univerziteta Crne Gore **da prihvati** disertaciju *" Mjerenje N-džetnosti varijabli u događajima sa produkcijom Z bozona u SMS detektoru i performance njegovog elektromagnetnog kalorimetra"* kandidata Jelene Mijušković i imenuje komisiju za odbranu doktorske disertacije u sastavu:

1. Dr Nataša Raičević, redovni profesor na Prirodno-matematičkom fakultetzu Univerziteta Crne Gore (naučna oblast: Fizika elementarnih čestica), mentor;
2. Dr Federico Ferri, istraživač sa habilitacijom (Habilitation a diriger des recherches), Institut CEA-IRFU, Saclay, Pariz, Francuska (naučna oblast: Fizika elementarnih čestica), komentor;
3. Dr Philippe Gras, istraživač sa stalnom pozicijom, Institut CEA-IRFU;Saclay, Pariz, Francuska, (naučna oblast: Fizika elementarnih čestica) supervisor;
4. Dr Marco Delmastro, istraživač sa habilitacijom (Habilitation a diriger desrecherches), direktor za istraživanje, LAPP; Universitet Savoie Mont Blanc, LAPP,CNRS/IN2P3, Annecy, Francuska, (naučna oblast: Fizika elementarnih čestica) eksterni evaluator;
5. Dr Ulla Blumenschein, senior predavač, School of Physics and Astronomy, Queen Mary University of London, Engleska (naučna oblast: Fizika elementarnih čestica) eksterni evaluator;
6. Dr Ivana Pićurić, redovni profesor na Prirodno-matematiočkom fakultetu (naučna oblast: Fizika elementarnih čestica),ispitivač;
7. Dr Lydia Iconomidou-Fayard, istraživač sa habilitacijom (habilitation a diriger desrecherches), direktor za istraživanje, CNRS, UClab, Universite Paris - Saclay, Orsay, Francuska, (naučna oblast: Fizika elementarnih čestica), ispitivač i
8. Dr Simone Alioli, vanredni profesor, Department of Physics "G:Occhialini", University of Milano- Bicocca, Italija (naučna oblast: Fizika elementarnih čestica), ispitivač.

III

Predlog se dostavlja Centru za doktorske studije i Senatu Univerziteta Crne Gore na dalju proceduru.

DEKAN

Prof. dr Predrag Miranović

OCJENA DOKTORSKE DISERTACIJE

OPŠTI PODACI O DOKTORANDU		
Titula, ime i prezime	Mr Jelena Mijušković	
Fakultet	Prirodno-matematički fakultet, UCG	
Studijski program	Fizika	
Broj indeksa	1/2018	
MENTOR/MENTORI		
Prvi mentor	Dr Nataša Raičević, Redovni profesor	Univerzitet Crne Gore
Drugi mentor	Dr Federico Ferri Istraživač sa habilitacijom (habilitation à diriger des recherches)	Institut CEA- IRFU, Saclay, Pariz, Francuska

KOMISIJA ZA OCJENU DOKTORSKE DISERTACIJE	
Dr Marco Delmastro, Istraživač sa habilitacijom (habilitation à diriger des recherches) - direktor za istraživanje, Eksterni evaluator za Univerzitet Paris-Saclay	LAPP, Universizy Savoie Mont Blanc, CNRS/IN2P3, Annecy, Francuska
Dr Ulla Blumenschein, senior istraživač Eksterni evaluator za Univerzitet Paris-Saclay	School of Physics and Astronomy, Queen Mary University of London, Engleska
Dr Philippe Gras, istraživač sa stalnom pozicijom	CEA-IRFU, Saclay, Pariz, Francuska
Dr Federico Ferri, istraživač sa habilitacijom (habilitation à diriger des recherches)	CEA-IRFU, Saclay, Pariz, Francuska
Dr Nataša Raičević, redovni profesor	Univerzitet Crne Gore, Crna Gora

Datum značajni za ocjenu doktorske disertacije	
Doktorska disertacija i Izvještaj Komisije dostavljen Biblioteci UCG	29.03.2022.
Javnost informisana (dnevne novine) da su Doktorska disertacija i Izvještaj Komisije dati na uvid	30.03.2022.
Sjednica Senata na kojoj je izvršeno imenovanje Komisije za ocjenu doktorske disertacije	9.03.2022.

Uvid javnosti	
U predviđenom roku za uvid javnosti bilo je primjedbi?	Ne.

OCJENA DOKTORSKE DISERTACIJE

1. **Pregled disertacije** (bibliografski podaci o disertaciji i sažetak disertacije)

Naučna oblast disertacije je Fizika elementarnih čestica koja se naziva i Fizika visokih energija. U radu su prikazana mjerenja diferencijalnog efikasnog presjeka za produkciju Z bozona i džetova koji nastaju u proton-proton sudarima pri energiji u sistemu centra mase od 13 TeV. Analizirani podaci dobijeni su sa CMS (Central Muon Solenoid) eksperimenta na akceleratoru LHC (Large Hadron Collider) u CERN-u tokom 2018. godine i odgovaraju integriranoj luminoznostu od 59

fb^{-1}. Fokus rada je mjerenje varijabli N-džetnosti, τ_N:

$$\tau_N = \sum_k \min\{q_a \cdot p_k, q_b \cdot p_k, q_1 \cdot p_k \cdots q_N \cdot p_k\}$$

gdje je p_k kvadri-impuls čestice k, q_a i q_b su kvadri-impulsi snopova, a $q_1,\ldots,q_N$ predstavljaju kvadri-impulse N džetova u događaju. U graničnom slučaju kada $\tau_N \to 0$, događaj sadrži N uskih džetova.

U ovom radu mjeri se efikasni presjek u zavisnosti od N-džetnost varijabli: nula-džetnost (τ_0), jedan-džetnost (τ_1) kao i zbir transverzalnih impulsa čestica kreiranih u interakciji. Osim ovih varijabli zasnovanih na kinematici rekonstruisanih naelektrisanih čestica, u ovom radu mjere se i varijable koje su zasnovane na kinematici rekonstruisanih džetova anti-kT algoritmom. Ove varijable definisane su na sljedeći način:

$$\tau_j = p_T^j \frac{1}{2\cosh(y_j - Y)},$$

gdje su p_T^j i y_j transverzalni impuls i rapiditet džeta, j, dok je Y rapiditet Z bozona. U radu su dobijeni efikasni presjeci u zavisnosti od $\tau_{max} = \max_j \tau_j$ i $\tau_{sum} = \sum_j \tau_j$.

Mjerenja opisanih varijabli su dobijena analizom događaja koji sadrže par rekonstruisanoh miona koji nastaju pri raspadu realnog Z bozona sa invarijantnom masom između 76 and 106 GeV kao i virtuelnih Z bozona sa invarijantnom masom između 125 i 150 GeV, 150 i 350 GeV i između 350 i 1500 GeV za četiri različita intervala transverzalnog impulse Z bozona.

Mjerenja su upoređena sa dva teorijska modela zasnovana na presjecima sa tzv. fiksiranim redom na nivou partona sa tačnošću do vodećeg reda (engl. leading-order – LO) ili sljedećeg vodećeg reda (engl. next-to-leading-order – NLO) u teoriji jake interakcije Kvantne hromodinamike (engl. Quantum ChromoDynamics – QCD) za različite multipliciteta lakih partona koji se spajanjem podudaraju sa nastalom partonskom kaskadom. Rezultati teorijskih modela dobijeni su korišćenjem generatora MadGraph5_aMC@NLO. Prvi model spaja od nula do četiri partona pri vodećem redu tj. LO dok se u drugom spajanje vrši od nula do dva pri NLO. Eksperimentalni rezultati su upoređeni i sa modelom zasnovanim na narednom-nakon-sljedećeg-reda (engl. next-to-next-to-leading order – NNLO) kombinovanim sa resumacijom članova višeg reda po 0-džetnost varijabli koji se podudaraju sa partonskim kaskadama dobijenim GENEVA generatorom događaja.

Jedan dio disertacije posvećen je izučavanju performansi i kalibraciji Elektromagnetnog kalorimetra (ECAL) sa CMS eksperimenta tokom RUN 2 perioda (2016, 2017 i 2018. godina). Ovaj detektor je krucijalna komponenta za detekciju fotona, elektrona i pozitrona i zbog toga je vrlo značajan za mnoge analize koje se izvode u CMS kolaboraciji.

Disertacija se sastoji od uvodnog dijela, pet poglavlja i zaključka. Pored toga, date su liste sa slikama i tabelama. Disertaciji prethodi apstrak napisan na crnogorskom, francuskom i engleskom jeziku. Teorijski uvod u Standardni Model je opisan u poglavlju 1. U poglavlju 2 opisan je CMS detektor. Interkalibracija i performance ECAL detektora opisane su u poglavlju 3. Mjerenja varijabli zasnovanih na kinematici rekonstruisanih naelektrisanih čestica predstavljena su u poglavlju 4 dok su mjerenja varijabli zasnovanim na rekonstruisanim džetovima predstavljena u poglavlju 5. Nakon toga slijede zaključci.

Poglavlje 1 opisuje teorijske osnove Standardnog Modela. Teorije i Lagranžijani koji opisuju fundamentalne inetrakcije su ukratko izloženi: kvantna elektrodinamika, kvantna hromodinamika i elektroslaba teorija. Glavni koncepti teorije Izvan Standardnog Modela (engl. Beyond the Standard Model) su diskutovani u potpoglavlju 1.1. Teorijski proračun efikasnog presjeka proton-proton interakcije sa kolinearnom faktorizacijom i Funkcijama raspodjele partona (engl.

Partong Density Functions – PDF) su opisani u dijelu 1.2. Nakon ovog opšteg dijela, u potpoglavlju 1.3 detaljno je objašnjen Drel-Jan proces. U potpoglavlju 1.4 uvode se Monte Carlo (MC) simulacije fizičkih procesa kao i odziva detektora koje imaju vrlo važnu ulogu za mjerenja i nova otkrića. Ključni koncepti generatora, MadGraph5_aMCc@NLO i GENEVA, korišćenih za uporedivanje eksperimentalnih rezultata i teorijskih predikcija su opisani.

Poglavlje 2 opisuje eksperimentalnu aparaturu. Protoni se ubrzavaju na sudaraču LHC. Protoni i čestice koje nastaju pri njihovim sudarima detektuju se u CMS detektoru. CMS je vrlo sofisticirana aparatura koja se sastoji od poddetektora zasnovanim na različitim tehnologijama. Kombinovanjem informacija sa subdetektora rekonstruiše se kinematika svakog sudara: identifikuju se nastale čestice i mjere se njihovi impulse i energije. U ovom poglavlju predstavljen je skceleratorski sitem i detektori CMS eksperimenta. U potpoglavlju 2.1 dat je kratak osvrt na LHC, njegov dizajn i performanse, rad i budući planovi. Potpoglavlje 2.2 je namijenjeno CMS eksperimentu. CMS koordinatni sistem i osnovne kinematičke varijable koje opisuju čestice kreirane u proton-proton interakcijama su definisane. Struktura i performance ključnih detektorskih komponenti CMS-a su ukratko predstavljene. Rekonstrukcija čestica u detektorima je opisana u potpoglavlju 2.3. Objašnjena je rekonstrukcija trajektorija nastalih čestica i verteksa, kao i identifikacija i rekonstrukcija elektrona, forona, miona kao i algoritam za rekontrukciju čestica korišćenjem informacija sa različitih detektorskih sistema (engl. Particle flow algorithm - PF). Ovo poglavlje zaključeno je potpoglavljem 2.4 koje opisuje nadgradnju CMS detektora koja se predviđa za fazu rada LHC-a sa visokom luminoznošću (HL-LHC period).

Kao što je ranije pomenuto, dio ove teze je posvećen interkalibraciji i izučavanju performansi elektromagnetnog kalorimetra CMS-a što je opisano u **Poglavlju 3**. Odlična rezolucija ovog kalorimetra ima važnu ulogu u mnogim fizičkim analizama koje se realizuju na CMS-u. Naročito, visoka preciznost mjerenja enrgije elektrona i fotona ovim kalorimetrom imala je esencijalni doprinos u otkriću Higs bozona kroz kanal raspada na dva forona, $H \rightarrow \gamma\gamma$, tokom Run 1 perioda rada LHC-a. Da bi se optimizirale performance detektora sprovedena je kalibracija relativnog odziva ECAL kanala i dobijene korekcije za varijacija odziva detektora tokom vremena. Tokom RUN 2 perioda, zbog značajnog povećanja luminoznosti tj. broja proton-proton interakcija u jedinici vremena, kreirani su zahtjevni uslovi na koje je ECAL morao što bolje odgovoriti.

Mjerenje enrgije i rekonstrukcija signala u ECAL-u su opisani u potpoglavljima 3.1 i 3.2. Pošto odziv ECAL-a varira tokom vremena zbog varijacija transparentnosti kristala izazvanih radijacijom, vršena je konstantna kalibracija kalorimetra. Laserski sistem za praćenje transparentnosti kristala je opisan u potpoglavlju 3.3. Dio ove disertacije posvećen je interkalibraciji ECAL-a korišćenjem Drel-Jan procesa tokom kojeg se kreira electron-pozitron par. Konstante interkalibracije dobijene su za sve tri godine tokom Run 2 perioda. Pored ovog, ova teza obuhvata i mjerenje rezolucije ECAL-a tokom Run 2 perioda i upoređivanje performansi rada ECAL-a tokom Run 1 i Run 2 perioda. U potpoglavlju 3.4 predstavljene su različite metode za interkalibraciju dok potpoglavlje 3.5 daje više detalja o korišćenju Drel-Jan procesa u ove svrhe. Planovi koji se odnose na nadgradnju ECAL-a tokom HL-LHC perioda opisani su u potpoglavlju 3.6.

U **Poglavlju 4** prikazana su mjerenja diferencijalnog efikasnog presjeka za produkciju Z bozona u funkciji N-džetnost varijabli, τ_0 and τ_1, kao i diferencijalni efikasni presjeci u zavisnosti od sume transverzalnih impulse naelektrisanih čestica. Sudari tj. interakcije u kojima se kreira Z bozon selektuju se kroz postojanje dva naelektrisana miona. Mjerenja su dobijena za realni Z i virtuelne Z bozone i fotone. Zbog velike luminoznosti, glavni izazov pri ovakvim mjerenjima je prisustvo čestica iz velikog broja proton-proton interakcija koje se preklapaju i dešavaju istovremeno sa interakcijom tokom koje se kreirao Z bozon, njih u prosjeku 35, tzv. *pileup* . Da bi se redukovao doprinos od čestica koje potiču od *pileup* dogadaja, pomenute varijable su računate samo

korišćenjem rekonstruisanih naelektrisanih čestica jer se za njih može odrediti da li potiču od tzv. primarnog verteksa tj. tačke u kojoj se desila interakcija od interesa. Mjerenja su vršena za četiri interval transverzalnog impulse Z bozona, , p_T (Z), i tri intervala dileptonskih masa (M_{ll}). U prvom dijelu ovog poglavlja (4.1) definisane su varijable koje će se mjeriti. U potpoglavlju 4.2 predstavljeni su uzorci anlaiziranih interakcija dobijenih iz eksperimentalnih podataka i iz simulacija korišćeni u ovom radu. Selekcioni kriterijumi korišćeni za odabir interakcija od interesa, kao i naelektrisanih čestica nastalih u njima predstavljeni su u potpoglavlju 4.3. Selekcija događaja tj. interakcije zasnovana je na identifikaciji miona čije su trajektorije rekonstruisane sa velikom preciznošću u detektoru za rekonstrukciju trajektorija naelektrisanih čestica i Mionskom sistemu. Osim ovog, zahtjeva se da ovi mioni budu izolovani tj. da ne pripadaju nekom džetu u kojem nastaju kao rezultat raspada drugih čestica – uglavnom hadrona. Takođe, za računanje τ_0, τ_1 i sumarnog transverzalnog impulse čestica uzimaju se u obzir samo naelektrisane čestice čiji je transverzalni impuls veći od 1GeV. Za sve čestice se zahtjeva se da se emituju unutar geometrijske oblasti koja je u potpunosti pokrivena detektorima tj. da je apsolutna vrijednost pseudorapiditeta $|\eta| < 2.4$.
Odziv detektora je detaljno simuliran sofisticiranim softverom uz modeliranje interakcije svake čestice sa materijalom detektora i uz emulaciju elektronike za očitavanje signala. Simulacija se upoređuje sa realnim podacima da bi se utvrdila eventualna razlika. Potpoglavlje 4.4 opisuje dobijanje korekcija koje se dodatno primjenjuju na simulirane događaje kako bi se unaprijedila tačnost simulacije. Ove korekcije su zajedničke za sve analize na CMS-u. Računanje ovih tzv. faktora skaliranja za primijenjeni trigger je dio rada ove doktorske disertacije i dobijeni su primjenom *Tag-and-Probe* metoda dok su ostale korekcije dobijene u okviru drugih CMS grupa. Nakon primjenjenih korekcija, raspodjele za mione i mionske parove upoređene su sa simulacijom. Ova poređena su urađena i za raspodjele kinematičkih veličina koje kojekarakterišu razmatrane naelektrisane čestice. Da bi se eksperimentalni rezultat upoređivao sa rezultatima teorijskih modela, mjerenja moraju biti korigovana za detektorske efekte koji utiču na rekonstrukciju čestica, a vezani su za neefikasnog detektora ili misidentifikacija čestica od interesa. Dodatno, pošto eksperimentalna aparatura ima ograničenu rezoluciju, izmjerena vrijednost neke opservable obično ne odgovaraju tačnoj vrijednosti i neophodno je primijeniti tehnike za dekonvoluciju detektorskih efekata koje su predtsavljene u potpoglavlju 4.5. U potpoglavlju 4.6 je detaljno obajašnjeno računaje svih prisutnih sistematskih grešaka. Ovaj dio takođe uključuje detaljno objašnjenjenje računanja teorijskih grešaka koje postoje usred primjene određenih modela. U potpoglavlju 4.7 predstavljeni su rezultati diferencijalnog efikasnog presjeka u zavisnosti od 0-džetnosti, 1-džetnosti i sumarnog transverzalnog impulsa naelektrisanih čestica. Rezultati su dobijeni za invarijantnu masu Z bozona, u oblasti pika, između 76 i 106 GeV, između 125 i 150 GeV, 150 and 350 GeV i 350 i 1500 GeV. Varijable su izmjerene i za četiri intervala transverzalnog impulse Z bozona: transverzalni impuls manji od 6 GeV, od 6 do 12 GeV, od 12 do 25 GeV i iznad 25 GeV. Eksperimentalni rezultati su upoređeni sa tri prethodno opisana teorijska modela.
Poglavlje 5 sadrži rezultate opservabli zasnovanih na rekonstruisanim džetovima. Ove opservable su izmjerene u događajima u kojima rekonstruisani Z bozon ima vrijednost mase u oblasti pika (realni Z bozon tj- Z bozon na masenoj ljusci). Definicije varijabli zasnovanih na džetovima, τ_{max} and τ_{sum}, predstavljene su u potpoglavlju 5.1. Objašnjen je i značaj mjerenja efikasnog presjeka u zavisnosti of ovih varijabla i njihova prednost u odnosu na standardne varijable koje opisuju džetove. Potpoglavlje 5.2 opisuje rekonstrukciju i selekciju džetova. Dva metoda za redukciju doprinosa džetova koji potiču od pileup-a su upoređena i usvojen je onaj koji je pogodniji za mjerenja N-džetnost varijabli. U poglavlju 5.3 objašnjene su dodatne sistematske greške koje se pojavljuju rekonstrukcijom džetova. Raspodjele po τ_{max} and τ_{sum} varijablama na niou detektora i prikazani su u potpoglavlju 5.4 i upoređene sa Monte Carlo

simulacijama. Rezultati za diferencijalni efikasni presjek po τ_{max} and τ_{sum} varijablama prikazani su na kraju ovog poglavlja. Data su poređenja eksperimentalnih rezultata i teorijskih modela koji su korišćeni i u poglavlju 4.
Na kraju, rezultati disertacije su sumirani u **Zaključcima.**

2. **Vrednovanje disertacije**

2.1. Problem (navesti neriješena i kontraverzna mišljenja o istraživačkom problemu i dosadašnjim pokušajima rješavanja problema, rješenja do kojih su došli drugi autori, ocjenu osnove disertacije u skladu sa radovima i istraživanjima kandidata i način njihove veze sa samom disertacijom)

Brojne analize na LHC-u kategorišu događaje tj. interakcije u zavisnosti od broja džetova koji se u njima kreiraju. Analize koje se odnose na procese u kojima se dešava fuzija vektorskih bozona (engl.Vector Boson Fusion – VBF) uobičajeno zahtijeva dva džeta koja su značajno razdvojena po rapiditetu – na primjer zahtjevanjem postojanja sistema od dva džeta sa velikom invarijantnom masom. Ovakve kategorizacije tj. selekcije podrazumijevaju postojanje faznog prostora sa restrikcijom na dodatno QCD zračenje. Ovakva restrikcija čini efikasni presjek osjetljivim na eventualnu "meku" (sa malim transverzalnim impulsom) i kolinearnu radijaciju i uvodi po svim redovima konstane jake interakcije, α_S, članove perturbacije $\alpha_s^n \log^{2n}(Q/p_T^{veto})$, gdje je Q energetska skala koja karakteriše događaj, a p_T^{veto} je prag za transverzalni impuls iznad kojeg su džetovi zabranjeni. Ukoliko je tzv. veto-uslov jači (niže p_T^{veto}), veći su logaritamski članovi. Zbog slabe konvergencije perturbacionog računa za efikasni presjek, članovi su posebno veliki u slučaju produkcije Higs bozona što vodi neodređenosti mjerenja od oko 11% za NNLO i oko 8% za NNLO+NLL (next-to-leading-logarithmic) proračune sa $p_T^{veto} = 25$ GeV uz primjenu anti-k_T algoritma za rekonstrukciju džeta sa parametrom rastojanja R = 0.5. Za male vrijednosti parametra rastojanja (R << 1), algoritam uvodi logaritamske članove po R koji doprinose NLL proračunima koji slabo konvergiraju. Frank J. Tackmann sa saradnicim apredložio je korišćenje inkluzivnih varijabli koje se mogu resumirati (imati konačnu vrijednost za red sa divergentnim članovima) i omogućavaju precizno računanje efikasnih presjeka uz korišćenje najsavremenijih proračuna. Dvije vrste varijabli su predložene, inkluzivne koje ne zavise od algoritma za rekonstrukciju džetova i zbog toga uprošćavaju resumaciju (τ_N), i varijable zasnovane na rekonstruisanim džetovima (τ_{max}). Za razliku od mjerenja sa džetovima, u literaturi postoji vrlo malo mjerenja koja upoređuju teorijska predviđanja za ove N-džetnost varijable sa eksperimentalnim rezultatima i ograničena su samo na τ_0. Ova teza popunjava upravo te praznine detaljnim mjerenjima ovih varijabli sa dva cilja: obezbjeđivanje pouzdanosti njihovog korišćenja kao džet-veto algoritma i obezbjeđivanje eksperimentalnih rezultata za resumaciju članova višeg reda.

2.2. Ciljevi i hipoteze disertacije

Glavni ciljevi

1. Mjerenje diferencijalnog efikasnog presjeka za udruženu produkciju Z bozona i džetova u proton-proton sudarima na energiji u sistemu centra masa od 13 TeV u funkciji od varijabla koje se zasnivaju na kinematici rekonstruisanih naelektrisanih hadrona: 0-džetnosti, 1-džetnosti i sume transverzalnih impulse naelektrisanih čestica za Z bozon u oblasti masenog pika, za pet intervala transverzalnog impulse: inkluzivni, ispod 6 GeV, između 6 i 12 GeV, izmedu 12i 25 GeV i iznad 25 GeV.

2. Mjerenje prethodno navedenih presjeka za virtuelni Z bozon velike mase u različitim intervalima invarijantnih masa: od 125 i 150 GeV, od 150 i 350 GeV i od 350 do 1500 GeV.

3. Mjerenje diferencijalnih efikasnih presjeka udružene produkcije Z bozona i džetova u proton-proton sudarima na energiji u sistemu centra masa od 13 TeV u funkciji od varijabla zasnovanih na rekonstruisanim džetovima: τ_{sum} i τ_{max}.

4. Upoređivanje eksperimentalno izmjerenih diferencijalnih efikasnih presjeka u funkciji N-džetnost varijabla sa najsavremenijim teorijskim proračunima.

5. Izučavanje performansi i interkalibracija elektromagnetnog kalorimetra tokom Run 2 perioda (2016, 2017 and 2018).

2.3. Bitne metode koje su primijenjene u disertaciji i njihovu primjerenost. Ako je primijenjena nova ili dopunjena metoda, opišite šta je novo

Eksperimentalni podaci analizirani u ovoj tezi dobijeni su korišćenjem CMS detektora u CERN-u u Ženevi. Ovaj detektor je jedna kompaktna struktura sa velikim brojem poddetektorskih sistema. Centralni dio je veliki superprovodni solenoid dužine 12.5 m i radijusa 6 m. Nominalna vrijednost magnetnog polja koje on proizvodi iznosi 4T. Unutar solenoida instalirani su: detektor za rekonstrukciju naelektrisanih čestica, ECAL i hadronski kalorimetar (HCAL).
Izvan solenoida je gvozdeni nosač magneta ispresijecan slojevima mionskih detektora. Da bi se rekonstruisale i identifikovale čestice korišćen je PF algoritam. Ovaj algoritam kombinuje informacije sa svih poddetektoa omogućavajući najbolju moguću identifikaciju i mjerenja energije svih vrsta objkata. PF algoritam koristi informacije iz detektora za rekonstrukciju trajektorija naelektrisanih čestica i mionskog sistema i kalorimetrijskih klastera rekonstruisanih u ECAL-u i HCAL-u. Ovaj algoritam omogućava rekonstrukciju fotona, neutralnih hadrona, naelektrisanih hadrona, elektrona i miona i omogućava rekonstrukciju džetova i određivanje nedostajućeg transverzalnog impulsa. Selekcija događaja započinje mionima čija je putanja ekstrapolirana iz detektora naeleketrisanih čestica konzistentna sa trajektorijom u mionskom sistemu dok se informacija o enrgiji dobija iz zakrivljenosti njihove putanje pri prolasku kroz magnetno polje.

Da bi se izmjerili efikasni presjeci u fizičkim analizama, neophodno je uporediti eksperimentalne podatke sa simulacijom kako bi se primijenile tehnike za dekonvoluciju detektorskih efekata. Proton-proton interakcije generisane su MADGRAPH5 AMC@NLO generatorom, a CMS detektorski sistem je modeliran korišćenjem GEANT4. Rekonstrukcija simuliranih događaja vrši se na identičan način kao u slučaju eksperimentalnih podataka. Da bi se analizirali eksperimentalni i simulirani poaci, zajednički softverski paket je razvijen u CMS kolaboraciji koji uključuje i softverski paket ROOT. Analiza u ovom radu je zahtjevala razvoj programa u C++ i Python programskim jezicima.

U ovoj disertaciji je izračunata efikasnost korišćenog mionskog trigera u eksperimentalnim i simuliranim podacima, a odnos ovih efikasnosti se koristi kao faktor skaliranja koji se dodatno primijenjuje na simulirane podatke. Da bi dobila faktore skaliranja, doktorandkinja je koristila tehnike zasnovane na samim podacima, *Reference trigger* i *Tag & Probe method*.

Sa ovom tezom, razvijen je novi metod klasifikacije događaja zasnovanim na broju džetova koji

je implementiran u CMS-u.

Takođe, metod korišćen za uporedivanje performansi ECAL-a tokom različitih vremenskih perioda je inovativan i prvi put se koristi u ovoj tezi. Omogućena je tzv. faktorizacija pileup efekata i njihovo isključivanje iz poređenja performansi. Podaci su prikupljani u uslovima povećane luminoznosti LHC-a, što je za performance detektora zahtjevnije okruženje. Zahvaljujući inovativnoj metodi predloženoj u ovom radu, bilo je moguće dokazati da se performance detektora nisu promijenile tokom godina i da se kalibracija detektora nije pogoršala tokom vremena.

2.4. Rezultati disertacije i njihovo tumačenje

Raspodjele varijable τ_0 su mjerene za različite transverzalne impulse Z bozona, $p_T(Z)$, i uporedene sa teorijskim predikcijama dobijenim aMC@NLO i GENEVA generatorima. Integral pod raspodjelom $p_T(Z)$ u oblasti ispod 1 GeV je u generatoru aMC@NLO niži nego u eksperimentalnim podacima, a ovo je naročito izraženo za srednje $p_T(Z)$ (< 12 GeV). Resumacija koja je uključena u GENEVA generatoru bolje opisuje ove eksperimentalne podatke za inkluzivnu $p_T(Z)$ raspodjelu i oblast gdje je $p_T(Z)$ manji od 6 GeV. Odstupanja su detektovana i za veće vrijednosti transverzalnih impulsa dostižući i 50% za fazni prostor ograničen na $p_T(Z)$>25 GeV. Kad je u pitanju cjelokupna raspodjela po τ_0, inkluzivna po $p_T(Z)$, teorijski proračun koji uključuje resumaciju obezbjeđuje bolje slaganje sa eksperimentalnim mjerenjima. Ograničivši se na $p_T(Z)$ ispod 6 GeV ili između 6 i 12 GeV, može se zaključiti da je nivo slaganja teorijskih proračuna i eksperimentalnih rezultata vrlo sličan. Za veće vrijednosti transverzalnog impulsa, $12 < p_T(Z) < 25$ GeV, eksperimentalni podaci se bolje opisuju aMC@NLO modelom. Dio raspodjele po τ_0 gdje τ_0 ima vijednost nižu od donje vrijednosti razmatranog $p_T(Z)$ čine uglavnom događaji sa hadronskom aktivnošću koja balansira transverzalni impuls izvan oblasti koju pokriva detektor. Teškoće da se reprodukuju raspodjele za tzv. pt-balans u događajima sa Z bozonom i džetovima u oblasti rapiditeta $|y| < 2.4$ detektovan je i ranije na CMS-u. Neslaganja eksperimentalnih i teorijskih raspodjela po τ_0 dobijena su i za transverzalne impulse veće od praga za $p_T(Z)$ i ona su slična za oba generator, aMC@NLO i GENEVA.

Raspodjele po τ_0 dobijene su i inkluzivno po $p_T(Z)$ uz zahtjev da Z bozon bude izvan masene ljuske tj. da bude virtuelan sa većim vrijednostima mase čime se povećava i doprinos od logaritamskih članova za efikasni presjek, $\alpha_s^n \log 2n\ (Q/p_T^{veto})$. Slaganje sa eksperimentalnim mjerenjima je slično za proračune sa i bez resumacije. Pokrivenost razlika između eksperimentalnih podataka i teorijskih proračuna neodređenostima koje se odnose na svaki od proračuna je lošija kod proračuna sa resumacijom za koje bismo očekivali bolju kontrolu neodređenosti kad je u pitanju ova varijabla.

Diferencijalni efikasni presjeci u zavisnosti od on τ_1 varijable mjereni su za iste invarijantne mase, $m_{\mu\mu}$, i $p_T(Z)$ intervale kao i τ_0. Tačnost ove opservable se očekuje da bude slična za GENEVA generator i proračune sa fiksiranim redom što je i potvrđeno u ovom radu. Oblici teorijskih raspodjela dobijeni različitim generatorima su slični a razlike su uglavnom u vrijednost ukupnog efikasnog presjeka. Za invarijantne mase u okolini Z pika, u oblasti u kojoj dominiraju partonske kaskade, dobijene su razlike i do 90% za male vrijednosti τ_1. Za veće vrijednosti $p_T(Z)$ između 25 i 35 GeV, predikcija koja uključuje maksimalni broj džetova u matričnom elementu najbolje opisuje eksperimentalne rezultate. GENEVA generator obezbjeđuje dobar opis eksperimentalnih mjerenja τ_1 varijable za mjerenja za sve oblasti invarijantnih masa iznad Z bika. Predikcije aMC@NLO proračuna su slične osim za interval $\tau_1 \in [0, 0.2]$ GeV i $p_T(Z) \in [125, 150$ GeV] gdje

je doprinos veći u odnosu na eksperimentalna mjerenja.

Rezultati za sumarni transverzalni impuls naelektrisanih čestica su dobijeni za iste intervale transverzalnog impulse i invarijantnih masa kao i τ_0 and τ_1. Za fazni prostor inkluzivan po $p_T(Z)$, GENEVA i aMC@NLO solidno opisuju eksperimentalne rezultate nezavisno od invarijantne mase, ali sa nešto ravnijom raspodjelom u slučaju aMC@NLO. Takođe, aMC@NLO daje dobru predikciju za fazni prostor ograničen na $p_T(Z) > 25$ GeV sa bozonom u oblasti Z pika.

Kad su u pitanju raspodjele zasnovane na džetovima, τ_{max} and τ_{sum}, postoje određena odstupanja GENEVA raspodjela u odnosu na eksperimentalne rezultate za niže vrijednosti τ_{max}. Za ostale oblasti τ_{max} svi teorijski modeli se slažu sa eksperimentalnim mjerenjima. U odnosu na eksperimentalne rezultate, svi generatori predviđaju izraženiji pik u τ_{sum} raspodjeli pri čemu je taj efekat najizraženiji u slučaju GENEVA generator. Teorijske neodređenosti dobijene GENEVA generatorom ne objašnjavaju ove razlike.

Da bi se dobio optimalan rad detektora, izvršena je kalibracija relativnog odziva kanala ECAL kalorimetra i primijenjene su korekcije na vremensku zavisnost odziva. Run 2 period sa povećanim nivoom pileup-a i zračenja predstavljao je zahtjevno okruženje za ECAL. U ovoj tezi dobijene su interkalibracione konstante korišćenjem događaja sa Drel-Jan parovima iz raspada $Z \rightarrow e^+e^-$ i proučavane performansi ECAL-a. Interkalibracione konstante dobijene su za sve tri godine tokom Run 2 perioda. Konstantni monitoring i kalibracija rezultirali su odličnim performansama ECAL-a. Energetska rezolucija za elektrone iz raspada Z bozona je na nivou od 1.7 % u oblasti niskih vrijednosti pseudorapiditeta. Takođe je pokazano da su performance ECAL-a tokom Run 2 perioda vrlo slične onima iz Run 1 perioda bez obzira na starost detektora i mnogo veću luminiznost sa LHC-a.

2.5. Zaključci (usaglašenost sa rezultatima i logično izvedeno tumačenje)

Diferencijalni efikasni presjeci izmjereni su u funkciji N-džetnost varijabli, onih koje su zasnovane na kinematici rekonstruisanih naelektrisanih čestica i onih koje su zasnovane na rekonstruisanim džetovima. Mjerenja su upoređena sa dva teorijska modela zasnovana na presjecima računatim korišćenjem kvantno-dinamičkih proračuna za efikasni presjek sa fiksiranim redom, LO ili NLO, za različite multiplicitete lakih partona koji se spajaju i podudaraju sa partonskom kaskadom. Ovi proračuni dobijeni su MadGraph5_aMC@NLO generatorom, pri čemu se u jednom slučaju spajanje vrši za multiplicitete od 0 do 4 pri LO a u drugom od 0 do 2 pri NLO. Eksperimentalna mjerenja su takođe upoređena sa predikcijama zasnovanim na NNLO u kombinaciji sa resumacijom članova višeg reda po 0-džetnost varijabli koje su dobijene GENEVA generatorom. Od varijabli koje nisu zasnovane na rekonstruisanim džetovima, mjerene varijable su: 0-džetnost, 1-džetnost i sumarni transverzalni impuls naelektrisanih čestica. N-džetnost varijable se mogu koristiti za zabranu događaja sa radijacijom visoke energije ili džetovima i da definišu teorijski dobro kontrolisani efiksni presjek za interakcije sa kreiranih N džetova. Ove varijable su takođe vrlo osjetljive na tzv. poddogađaje koji predstavljaju čestice koje potiču od dodatnih interakcija partona iz istog proton-proton sudara i zbog toga njhovo mjerenje predstavlja vrlo važan dio koji će doprinijeti razvoju teorijskih modela i razumijevanju interakcije.
Ova mjerenja dobijena su za interakcije u kojima je kreiran dimionski par nastao raspadom Z bozona sa masene ljuske (realnog) sa invarija invarijantnom masom između 76 i 106 GeV, i Z bozon van masene ljuske (virtuelni) sa invarijantnom masom između 125 i 150 GeV, 150 i 350

GeV i 350 i 1500 GeV. Ove varijable su takođe mjerene za četiri intervala transverzalnog impulsa Z bozona. Mjerenja za realne bozone pokazuju da je oblast niskih vrijednosti 0-džetnosti u inkluzivnnom slučaju najbolje opisana teorijskim proračunom dobijenim GENEVA generatorom. U oblasti sa velikim impulsom Z bozona gdje se očekuje kreacija jednog ili više džetova zajedno sa Z bozonom, MADGRAPH5 aMC@NLO daje najbolje rezultate. Za oblasti sa većom invarijantnom masom, svi teorijski modeli pokazuju solidno slaganje sa eksperimentalnim rezultatima. Mjerenja ovih varijabli pokazuju dobar potencijal za proučavanje poddogadaja. Proučavanjem ovih varijabla za invarijantne mase iznad mase Z pika, radi se u režimu sličnom produkciji Higs bozona.

Dobijeni su rezultati za N-džetnost varijable zasnovane na rekonstruisanim džetovima τ_{max} i τ_{sum}. Ove varijable su definisane korišćenjem transverzalnog impulse džeta sa težinskim faktorom koji zavisi od rapiditeta džeta. Ove varijable daju mogućnost da se postigne značajno isključenje događaja sa džetovima u centralnoj oblasti rapiditeta dok je u oblasti tzv. prednjih rapiditeta ovaj efekat manji. Eksperimentalna mjerenja τ_{max} varijable pokazuju dobro slaganje sa teorijskim rezultatima naročito sa MadGraph5_aMC@NLO. Stoga, ova varijabla se može koristiti za restrikciju događaja sa kreiranim džetovima.

3. Konačna ocjena disertacije

3.1. Usaglašenost sa obrazloženjem teme

Obje teme teze, fizička mjerenja i optimizacija performansi detektora, detaljno su istražene. Rad je u potpunosti usaglašen sa obrazloženjem teme.

3.2. Mogućnost ponovljivosti

Mjerenja iz disertacije su dobijena korišćenjem podataka sa CMS eksperimenta. Istraživanja pod identičnim uslovima mogu se ponoviti korišćenjem eksperimentalnih podataka sa ATLAS eksperimenta. Takođe, mjerenja se mogu ponoviti na oba seta podataka korišćenjem raspada Z bozona na elektron-pozitron par.

Ipak, analiza je složena i biće teško da je reprodukuje neko van CMS kolaboracije.

Numerička forma rezultata biće objavljena, pored publikacije u časopisu, u HEPDATA (https://www.hepdata.net/) i biće uključena u Robust Independent Validation of Experiment and Theory - Rivet, (https://rivet.hepforge.org/) da omogući poređenje sa bilo kojim proračunom.

3.3. Buduća istraživanja

Teza ima za cilj proučavanje novih varijabli čije se korišćenje predlaže umjesto veta na džetove u analizama u fizici visokih energija. Rad je pokazao da je modeliranje N-džetnost varijabli Monte Karlo generatorima lošije od modeliranja standardno korišćenih varijabla za džetove. Stoga je neophodno istraživanje koje će voditi poboljšanju teorijskih proračuna, prvo zbog njihove upotrebe u analizi podataka, a zatim i zbog razumijevanja resumacije članova viših redova.

3.4. Ograničenja disertacije i njihov uticaj na vrijednost disertacije

Nema posebnih ograničenja.

Orginalni naučni doprinos

(dati pojašnjenje: originalnost (originalnost(sasvim nova saznanja, dopuna/proširenje postojećeg znanja ili pobijanje postojećeg znanja), uticaj rezultata disertacije na napredak naučne oblasti, uticaj rezultata na struku (direktno, indirektno))

Ovaj rad doprinosi razumijevanju i modeliranju radijacije mekih gluona u proton-proton sudarima. U radu su dobijena mjerenja varijable koja je uvedena 2010. godine i koja se od nedavno koristi za računanje efikasnih presjeka sa izvanrednom tačnošću koristeći proračune sa NNLO po konstanti jake interakcije, α_s, kombinovane sa logaritamskim članovima do NNLL i partonskom kaskadom. Proračuni koji uključuju partonske kaskade su veoma značajni i sa eksperimentalnog stanovišta jer omogućavaju simulaciju proton-proton sudara uključujući odziv detektora što nije slučaj sa proračunima sa fiksiranim redom. Simulacija je neophodna u eksploataciji podataka sa eksperimenata kakav je CMS. N-džetnost varijabla je do sada mjerena samo u posebnom slučaju kada je N = 0 (0-džetnost). U ovoj tezi dobijeno je prvo mjerenje za $N \geq 1$.
Doprinos članova višeg reda je veći u slučaju produkcije Higs bozona. Sličan režim se može postići korišćenjem događaja sa produkcijom Z bozona zahtijevajući da je bozon van masene ljuske i da ima veću masu. Z bozoni koji se na LHC-u proizvode u ogromnom broju, korišćeni su kao zamjena za razumijevanje rijetke produkcije Higs bozona i validacije teorijskog proračuna efikasnih presjeka. Pored toga, ova varijabla se može iskoristiti i za redukciju i identifikaciju različitih mehanizama produkcije Higs bozona koje karakteriše kreacija nekoliko džetova u konačnom stanju.
ECAL detektor obezbjeđuje detekciju i mjerenje energije fotona, elektrona i pozitrona i stoga je ključna komponenta detektorskog sistema CMS eksperimenta. Za dobijanje rezultata visoke preciznosti i nova otkrića neophodne su odlične performance ovog detektora.

Mišljenje i prijedlog komisije

U radu su predstavljena prva mjerenja N-džetnost varijabli pri produkciji realnih i virtuelnih Z bozona u CMS eksperimentu i performanse njegovog elektromagnetnog kalorimetra.
Zbog dobre konvergencije perturbativnog reda za računanje efikasnog presjeka, produkcija Z bozona je odličan poligon za testiranje resumacije članova višeg reda i njihovo upoređivanje sa teorijskim modelima. Režim resumacije sličan kreaciji Higs bozona moguće je postići analizirajući Z bozone veće mase - van masene ljuske.
Elektromagnetni kalorimetar igra ključnu ulogu u detektorskom sistemu CMS-a i zahvaljujući doprinosu iz ove disertacije obezbijeđena je veoma dobra rezolucija što je od vitalnog interesa za naučni program CMS kolaboracije.
Rezultati disertacije su prikazivani na međunarodnim konferencijama i vorkšopovima koje organizuje CMS kolaboracija. Dio rezultati rada na elektromagnetnom kalorimetru objavljeni su u časopisu *Journal of Instrumentation* koji je vodeći časopis u instrumentaciji fizike čestica.

Jelena Mijušković on behalf of the CMS collaboartion

„The CMS electromagnetic calorimeter upgrade: high-rate readout with precise time and energy resolution",

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U pripremi je i publikacija mjerenja N-džetnost varijable. Nacrt rada je trenutno u fazi interne recenzije u okviru CMS kolaboracije.

Imajući u vidu sve navedeno, Komisija sa zadovoljstvom predlaže Vijeću Prirodno-matematičkog fakulteta Univerziteta Crne Gore da prihvati doktorski disertaciju pod nazivom „Mjerenje N-džetnost varijabli u događajima sa produkcijom Z bozona u CMS detektoru i performanse njegovog elektromagnetnog kalorimetra" kandidata Mr Jelene Mijušković kao i da predloži Senatu da imenuje Komisiju za odbranu ove doktorske disertacije.

Izdvojeno mišljenje

(popuniti ukoliko neki član komisije ima izdvojeno mišljenje)

Ime i prezime

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Napomena

(popuniti po potrebi)

KOMISIJA ZA OCJENU DOKTORSKE DISERTACIJE	
Dr Marco Delmastro, istraživač sa habilitacijom, direktor za istraživanje, LAPP, Univerzitet Savoie Mont Blanc, CNRS/IN2P3, Annency, Francuska	
Dr Ulla Blumenschein, senior predavač, School of Physics and Astronomy, Queen Mary, University of London, Engleska	
Dr Philippe Gras, istraživač sa stalnom pozicijom, CEA-IRFU, Saclay, Pariz, Francuska	
Dr Federico Ferri, istraživač sa habilitacijom, CEA-IRFU, Saclay, Pariz, Francuska	
Dr Nataša Raičević, redovni profesor, Univerzitet Crne Gore, Crna Gora	

Datum i ovjera (pečat i potpis odgovorne osobe)

Podgorica,
30.05.2022.

DEKAN

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MP

OCJENA DOKTORSKE DISERTACIJE

OPŠTI PODACI O DOKTORANDU		
Titula, ime i prezime	Mr Jelena Mijušković	
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Studijski program	Fizika	
Broj indeksa	1/2018	
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Prvi mentor	Dr Nataša Raičević, Redovni profesor	Univerzitet Crne Gore
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Dr Marco Delmastro, Researcher with the HDR (habilitation à diriger des recherches), research director External reviewer for University Paris-Saclay	LAPP, Universizy Savoie Mont Blanc, LAPP, CNRS/IN2P3, Annecy, France
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Datum značajni za ocjenu doktorske disertacije	
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Sjednica Senata na kojoj je izvršeno imenovanje Komisije za ocjenu doktorske disertacije	9.03.2022.

Uvid javnosti	
U predviđenom roku za uvid javnosti bilo je primjedbi?	No.

EVALUATION OF THE DOCTORAL THESIS

1. **Dissertation overview** (bibliographic data on the dissertation and dissertation summary)

The scientific area of the thesis is Elementary Particle Physics also called High Energy Physics. This thesis presents the measurements of the differential cross section of Z boson production in association with jets in proton-proton collisions at center of mass energy of 13 TeV. The analysed data has been collected by the CMS (Central Muon solenoid) experiment of LHC (Large Hadron Collider) during the year 2018 and corresponds to an integrated luminosity of 59

fb^{-1}. The main focus of the thesis is the measurement of N-jettiness variables, τ_N:

$$\tau_N = \sum_k \min\{q_a \cdot p_k, q_b \cdot p_k, q_1 \cdot p_k \cdots q_N \cdot p_k\}$$

where p_k is the four-momentum of particle k, q_a and q_b are the four-momenta of the beams and $q_1,\ldots,q_N$ represents the four-momenta of N jets in the event. For events with at least N jets, in the limit when $\tau_N \to 0$, the event contains N narrow jets.
In this thesis, the cross section is measured as a function of track-based event shape variables: zero-jettiness (τ_0), one-jettiness (τ_1) and the sum of the transverse momentum of particles.
Beside the track based variables, the so called jet based variables are also measured. These variables use jets reconstructed with the anti-k_T algorithm. Jet based variables, are defined via:

$$\tau_j = p_T^j \frac{1}{2\cosh(y_j - Y)},$$

where p_T^j and y_j are transversal momentum and rapidity of jet j and Y is Z boson rapidity. The cross section measurements depending on $\tau_{max} = \max_j \tau_j$ and $\tau_{sum} = \sum_j \tau_j$ are presented.

The measurements of event shape variables are performed for the events where pairs of muons are produced in the decay of a Z boson on-shell with an invariant mass between 76 and 106 GeV and also for off-shell Z bosons with an invariant mass between 125 and 150 GeV, 150 to 350 GeV and 350 and 1500 GeV and in four different Z boson transverse momentum regions.
The measurements have been compared with two theoretical predictions based on fixed-order parton-level cross sections calculated at LO (leading order) or NLO (next-to-leading order) accuracy in QCD for different ligh-parton multiplicities, merged and matched with parton shower. They have been computed with MadGraph5_aMC@NLO. The former merges multiplicities from zero to four at LO, and the latter from zero to two at NLO. The measurements are also compared with a predication at NNLO at fixed order combined with the resummation of higher-order terms in 0-jettiness and matched with parton shower obtained with the GENEVA event generator.
Part of the thesis is devoted to the studies of the performance and the calibration of the Electromagnetic calorimeter (ECAL) of CMS during the Run 2 data taking period (2016, 2017 and 2018 years). This subdetector is crucial for the detection of photons, electrons and positrons and is therefore very important for many analyses in CMS.
This thesis consists of an introductory part, five chapters and a conclusion. The list of figures and tables are provided. The dissertation is preceded by an abstract written in Montenegrin, French and English. The theoretical introduction to the Standard Model is described in chapter 1. In chapter 2, the CMS detector is presented. Intercalibration and performance of ECAL is described in chapter 3. The measurements of track-based event shape variables are presented in chapter 4, and the measurements of jet-based event shape variables are presented in chapter 5. Summary and conclusions follows.
Chapter 1 describes the theoretical basis of the Standard Model. The theories and Lagrangians that describe fundamental interactions are briefly summarized: quantum electrodynamics, quantum chromodynamics and electroweak theory with electroweak symmetry breaking. Main concepts Beyond the Standard Model theory are discussed and conclude section 1.1 of this chapter. The theoretical treatment of the computation of the cross-section of proton-proton interactions, with collinear factorisation and Parton Density Functions are descried in section 1.2. After this general part, in section 1.3 Drell-Yan processes are explained in detail. The section 1.4 introduces Monte Carlo (MC) simulations which include physics processes and also the response of the detectors and have very important role for measurements and new discoveries. The main concepts of generators used in the comparison of data and theoretical predictions,

MadGraph5_aMCc@NLO and GENEVA are described.

Chapter 2 describes the experimental setup. Protons are accelerated in the LHC and the particles produced in their collisions are detected with the CMS detector. CMS is a very sophisticated apparatus made of subdetectors using different technologies. By combining the information from the subdetectors, the complete kinematics of each collision is reconstructed: the produced particles are identified and their momenta and energies are measured. In this chapter, the accelerator system and the detector with its subsystems are presented. In section 2.1 a brief description of LHC, its design, performance, operation and future plans are given. Section 2.2 is devoted to the CMS experiment. The CMS coordinate system and the main the kinematic variables that describe particles created in proton-proton interactions are defined. The design and performance of the key components of CMS are briefly described. After this, the concept and logic of the trigger system is explained. The reconstruction of particles inside the detector is described in section 2.3. It explains track and vertex reconstruction, electron and photon reconstruction, muon reconstruction as well as the particle flow algorithm (PF) based on information from different detector systems. This chapter is concluded by section 2.4 in which the CMS upgrade for the phase of high luminosity (HL) is described.

As mentioned above, a part of the thesis is devoted to intercalibration and performance studies of the CMS electromagnetic calorimeter, which is described in **Chapter 3**. The excellent resolution of the CMS electromagnetic calorimeter plays an important role in many physics analyses performed at CMS. In particular, its precise measurement of the electron and photon energy had an essential contribution in the discovery of the Higgs boson through the $H \rightarrow \gamma\gamma$ channel during the LHC Run 1 period. In order to optimize the performance, a calibration of the relative response of the ECAL channels and corrections for the response variation in time are performed. The Run 2 data taking period, with the increased pileup and radiation level, created a challenging environment for ECAL.

The energy measurement and signal reconstruction in the ECAL are described in sections 3.1 and 3.2. Since the response of the ECAL varies with time due to the crystal transparency variation induced by irradiation, constant calibration of the detector is performed. The laser monitoring system used for monitoring the crystal transparency is described in Section 3.3. A part of this PhD work was devoted to the intercalibration of the ECAL using the Drell-Yan process where electron-positron pairs are produced. The intercalibration constants were obtained for all three years of the Run 2 period. In addition, this thesis includes work on resolution studies for the Run 2 period and a comparison of the performance of ECAL during Run 1 and Run 2. In section 3.4 the different intercalibration methods are described while section 3.5 provides more detail on the one exploiting the Drell-Yan processes. The plans for the ECAL barrel readout electronics for the HL-LHC are described in Section 3.6.

In **Chapter 4**, the measurements of the differential cross section for the production of a Z boson as a function of track based event shape variables, τ_0 and τ_1, and as function of the sum of the transverse momentum of charged particles are presented. The Z bosons are selected by their decay channel into two muons. The measurement is done for both on- and off- shell bosons and includes also the contribution from γ^*. The main challenge for these measurements is the presence in the recorded events of many overlaping proton-proton collisions, 35 on average, called pileup and occurring at the same time as the collision producing the Z boson because of the high luminosity of the colliding beams. To suppress the contribution from pileup, the selected particles are required to issue from the primary vertex of the interaction of interest. The event shape variables are computed with charged particles only in order to constrain the contributions coming from the pileup particles.

The measurements are performed in four different transverse momentum, p_T (Z), regions and in

three different dilepton mass (M_{ll}) regions. In the first part of this chapter (Section 4.1), the measured variables are defined. In Section 4.2, data samples and simulated samples are presented. The selection criteria for the events and for the particles used for the N-jettiness calculation are described in Section 4.3. The event selection is based on the identification of two muons with high quality tracks combined from the tracker and muon systems. Beside the track quality these muons are required to be well isolated from jets to exclude muons produced in hadron decays. In addition, it is required that one of the two muons has a transverse momentum above 25 GeV and the other above 20 GeV. Charged particles selected for the calculation of track-based variables are required to have a minimum transverse momentum of 1 GeV. Only particles within the tracker pseudorapidity full-precision acceptance, $|\eta| < 2.4$, are considered.
The response of the detector is simulated in detail with a sophisticated software modeling the interaction of each particle with its material and emulating the readout electronics. The simulation is compared with the real data to measure any difference. The Section 4.4 describes the extraction of corrections which are then applied to further improve the accuracy of the simulation. These corrections are common to all the analyses performed with the CMS data. The calculation of the trigger scale factor was part of the thesis work and has been done using the *Tag-and-Probe* method, while the other corrections were computed by some other CMS collaborators. After the corrections were applied, the detector distributions of muon and muon pairs were compared with the simulation. The comparison was also done for the track variables. In order to compare the obtained results with the theoretical predictions or with the results from other experiments, the measurements have to be corrected for the detector effects such as object reconstruction, inefficiency inside the acceptance of the detector and the misidentification of the objects of interest. In addition, since the reconstruction system has a finite resolution, the measured value of an observable usually does not correspond to the true one. The techniques for the deconvolution of the detector effects are presented in Section 4.5. In section 4.6, the following systematic uncertainties were explained and calculated. This section also includes a detailed explanation of the theoretical prediction uncertainties. The measurements of track-based variables are shown in section 4.7. The measurements are performed for events with a Z boson with invariant mass between 76 and 106 GeV, corresponding to the peak region, 125 and 150 GeV, 150 and 350 GeV and 350 and 1500 GeV. Track-based variables are also measured in four different Z boson transverse momentum regions: bellow 6 GeV, from 6 to 12 GeV, from 12 to 25 GeV and above 25 GeV. The measurements have been compared with the three theoretical predictions described in the introduction.
Chapter 5 contains the results of measurements of jet based event shape observables in the production of the Z boson in association with jets. These observables are measured in events with a Z boson in the mass peak region. The definitions of the jet based observables, τ_{max} and τ_{sum}, are presented in Section 5.1. The importance of the cross section measurement dependence on such variables and their advantages with respect to the jets selection according to their transverse momentum value is explained. Section 5.2 describes jet reconstruction and selection. Two methods of suppression of the pileup contribution from the jet reconstruction are compared and the one more appropriate for the N-jettiness measurements is adopted. Section 5.3 explains additional systematic uncertainties which arise due to the jet selection: the jet energy scale and jet energy resolution uncertainties. The results are presented in section 5.4 starting with results on all the uncertainties of the jet based variables. The detector level distributions comparison between data and Monte Carlo are shown. The results on the differential cross sections on jet based variables conclude this chapter. The experimental measurements are compared with the same theory calculations as used in chapter 4.
Finally, the results of the thesis are summarized in the **Conclusion**.

2. Dissertation evaluation

2.1 **Problem** (state unresolved and controversial opinions about the research problem and previous attempts to solve the problem, solutions reached by other authors, assessment of the dissertation basis in accordance with the publications and research of the candidate and the way they relate to the dissertation)

A number of data analyses at the LHC categorise events according to their number of hadronic jets. Analyses selecting a vector boson fusion (VBF) process typically require two jets separated with a rapidity region gap with a low hadronic activity, for instance by requiring a two-jet system with a large invariant mass. Such categorisations or selections imply a phase space with a restriction on additional QCD emissions. The restriction makes the cross section sensitive to soft and collinear radiation and introduces at all orders of strong coupling constant,α_S, of the perturbative calculation $\alpha_s^n \log^{2n}(Q/p_T^{veto})$ terms, where Q is the event energy scale and p_T^{veto} the p_T threshold above which jets are vetoed. The more stringent is the veto (lower p_T^{veto}), the larger are the logarithm terms. Because of the poor convergence of the perturbative calculation of the cross section, the terms are particularly large for the Higgs boson production, leading to uncertainty of about 11% for an NNLO calculation and up to 8% for an NNLO+NLL (next-to-leading-logarithmic) calculation with $p_T^{veto} = 25$ GeV and anti-k_T jet clustering algorithm with a distance parameter of R = 0.5. For small distance parameter values (R << 1), the clustering induces logarithmic terms in R, that contribute at NLL in the exponent of the cross section, which are difficult to resume. Frank J. Tackmann et al. proposed the use of inclusive variables that can be resumed at higher order and allow reaching an accurate cross section calculation with state-of-the art calculations. Two types of variables have been proposed, inclusive ones that do not depend on a jet clustering algorithm, and therefore simplify the resummmation (τ_N), and jet-based ones, more straightforward to use experimentally (τ_{max}). Contrary to jets, there are very few measurements in the literature that confront the predictions for these variables with the experimental data and they are limited to τ_0. This thesis fills the gaps by providing details measurements of these variables with two goals, giving confidence in using them as jet veto and providing experimental results for higher-order term resummation.

2.2 Goals and hypotheses of the dissertation

The main goals

1. The measurements of differential cross sections of Z boson production in association with jets in proton-proton collisions at the center-of-mass energy of 13 TeV as functions of track-based event shape variables: zero-jettiness, one-jettiness and sum of the transverse momentum of the charged particles for a Z boson in the mass peak region, for five transverse momentum regions, inclusive, below 6 GeV, between 6 and 12 GeV, between 12 and 25 GeV and above 25 GeV.

2. The measurements of the same differential cross sections for an off-shell Z boson of high mass, in different mass interval, between 125 and 150 GeV, 150 to 350 GeV and 350 and 1500 GeV.

3. The measurements of differential cross section of Z boson production in association with jets in proton-proton collisions at center of mass energy of 13 TeV as a function of jet-based event shape variables: τ_{sum} and τ_{max}.

4. The comparison of the differential cross section measurements of N-jettiness variables with state-of-the art theoretical calculations.

5. The studies of the performance and intercalibration of the Electromagnetic calorimeter during Run 2 data taking period (2016, 2017 and 2018).

2.3 Essential methods applied in the dissertation and their suitability. If a new or amended method has been applied, describe what is new

The data used in this thesis are obtained by using the CMS detector at CERN in Geneva. This detector has a compact structure with a lot of subdetector systems. The central part is a large superconducting solenoid with a length of 12.5 m and a radius of 6 m. The nominal value of magnetic field that it can produce is 4T. Inside the solenoid the tracking detector, the electromagnetic calorimeter (ECAL) and the hadron calorimeter (HCAL) are all installed. Outside the solenoid is the iron return yoke of the magnet, interleaved with layers of muon detectors.
In order to reconstruct and identify particles the algorithm called PF algorithm is used. This algorithm combines the information of all the subdetectors, enabling the best possible identification and energy measurements for all types of objects. The PF algorithm uses information about tracks from the tracker and muon system, and calorimeter clusters from the ECAL and HCAL. This algorithm allows us to reconstruct photons, neutral hadrons, charged hadrons, electrons and muons and it also provide us jet reconstruction and missing transverse momentum determination. The event selection starts with muons whose path extrapolated from the tracker is consistent with a muon track from the muon system and information about the energy is obtained from the curvature of the track.

To obtain the cross section measurements in the physics analysis, it is necessery to compare experimental data with the simulation in order to apply the techniques for the deconvolution of detector effects. Proton – proton interaction is generated using the MADGRAPH5 AMC@NLO generator and the CMS detector itself is modelled using GEANT4. Reconstruction of simulated events has ben done in the same way as for the experimental data. To analyse both experimental and simulated data, a common software framework developed by the CMS collaboration together with the ROOT data analysis framework is used. The analysis has required the development of programs in the C++ and Python languages.

In this thesis, the efficiencies of the double muon trigger used in the analysis were obtained for data and simulation and the ratio of the two has been used as scale factor corrections applied to the simulated data. For this, the combination of two data-driven techniques, the *Reference-trigger* and the *Tag & Probe*, are used.

With this thesis a new method for the classification of events based on the number of jets has been implemented in CMS.

The method used to compare the ECAL performance across years has been innovative and has been used for the first time in this thesis. It has allowed to factor the effects of pileup out of the performance comparison. Datasets have been acquired under increasing LHC luminosity, which

has been an increasing challenge from the detector point of view. Thanks to the innovative method proposed in the thesis, it has been possible to prove that the performance has remained consistent across years and that the calibration of the detector has not degraded over time.

2.4 Results of the dissertation and their interpretation

The distributions of τ_0 measured for different transverse momentum of the Z boson, $p_T(Z)$, have been measured and compared with the predictions computed with aMC@NLO and GENEVA. The integral below $p_T(Z)$ of 1 GeV is underestimated by the aMC@NLO predictions especially for low and moderate $p_T(Z)$ (< 12 GeV). The resummation included in GENEVA improves the prediction of this integral for the distribution inclusive in $p_T(Z)$ and restricted to values below 6 GeV. Discrepancies are observed for higher transverse momentum reaching 50% for a phase space restricted to $p_T(Z) > 25$ GeV. When considering the full range of the distribution, the prediction including the resummation provides a better description of the measurement for a phase space inclusive in $p_T(Z)$. When $p_T(Z)$ is restricted to either be below 6 GeV or between 6 and 12 GeV, the level of agreement is similar for the predictions with and without the resummation. For larger values, $12 < p_T(Z) < 25$ GeV interval and especially for $p_T(Z) > 25$ GeV, the data are better described with the aMC@NLO predictions. The part of the distribution with τ_0 below the $p_T(Z)$ threshold must be mainly populated by events with a hadronic activity balancing the p_T outside the pseudorapidity acceptance. Difficulty to reproduce the p_T -balance in Z+jets events with the jet rapidity restricted to $|y| < 2.4$ has been observed before by CMS. Discrepancies in the τ_0 distribution are also observed for value above the $p_T(Z)$ threshold with a shape similar between aMC@NLO and GENEVA.

The τ_0 distribution has also been measured inclusively in $p_T(Z)$ requiring the boson to be off-shell with a larger mass enlarging the contribution from the cross section logarithmic term, $\alpha_s^n \log 2n\ (Q/p_T^{veto})$. The agreement with the measurement is similar for the calculation with and without the resummation. The coverage of the difference with the measurement by the uncertainty estimated by the respective calculation is worst for the calculation with resummation, for which we would have expected a better control of the uncertainties.

The differential cross sections depending on τ_1 have been measured for the same $m_{\mu\mu}$ and $p_T(Z)$ intervals as τ_0. The accuracy for this observable is expected to be similar for GENEVA and fixed order calculations and this is confirmed by the observation. The shape of the three predictions are similar and differences are mostly on the total cross section values, computed at different orders. For a mass around the Z peak, discrepancies up to 90% are observed at low values of τ_1, in a region covered by the parton showering. For $p_T(Z)$ between 25 and 35 GeV, the prediction that includes the maximum number of jets in the ME is the closest to the measurement. The GENEVA prediction provides a good description of the measurement for all the mass regions above the Z boson peak and τ_1 bins. The predictions from aMC@NLO calculations are similar except for the $\tau_1 \in [0, 0.2]$ GeV bin and $p_T(Z) \in [125, 150]$ GeV, where it overshoots the data.

The results on the sum of the charged particle p_T are obtained for the same dimuon mass and $p_T(Z)$ bins as τ_0 and τ_1. For a phase space inclusive in $p_T(Z)$, the GENEVA and aMC@NLO predictions describe fairly the data independently of the dilepton mass, but with a flatter distribution around 10 GeV for aMC@NLO FxFx for all mass ranges and for both FxFx and kT-MLM for the off-shell regions. In addition, the aMC@NLO predictions provide a good description when the phase space is restricted to $p_T(Z) > 25$ GeV with a boson in the mass peak.

Concerning jet-based variables, τ_{max} and τ_{sum}, some discrepancies are observed for the lower value bin of τ_{max} between the GENEVA prediction and the data. For the rest of the τ_{max} all the predictions match with the measurement. All the generated samples predict a more prominent peak of the τ_{sum} distribution, with a more pronounced effect for GENEVA. The uncertainties computed for GENEVA do not cover the observed difference with the measurement.

In order to optimize the performance, a calibration of the relative response of the ECAL channels and corrections for the response variation in time are performed. The Run 2 data taking period, with the increased pileup and radiation level, created a challenging environment for ECAL. The work in the thesis included delivering the intercalibration constants using the Drell-Yan pairs from the $Z \rightarrow e^+e^-$ decay and studying the performance of ECAL. The intercalibration constants were derived for all three years of the Run 2 data-taking period. The constant monitoring and calibration resulted in excellent performance of ECAL during Run 2. The energy resolution for electrons from Z-boson decays is at the level of 1.7% in the low pseudorapidity region. It was also shown that the performance with Run 2 data is very close to the one from Run 1 despite the ageing of the detector and much higher instantaneous luminosity provided by the LHC.

2.5 **Conclusions** (consistency with results and logical interpretation)

Differential cross sections have been measured as a function of track-based event shape variables and as a function of jet-based event shape variables. The measurements have been compared with two theoretical predictions based on fixed-order parton-level cross sections calculated at LO or NLO accuracy in QCD for different ligh-parton multiplicities, merged and matched with parton shower computed with MadGraph5_aMC@NLO, one merging multiplicities from zero to four at LO and the other from zero to two at NLO. The experimental measurements have also been compared with a predication at NNLO at fixed order combined with the resummation of higher-order terms in 0-jettiness and matched with parton shower obtained with GENEVA. Track-based variables that have been measured are the zero-jettiness, one-jettiness and the sum of the transverse momentum of charged particles. These variables can be used as a veto for hard radiation or jets and to define a theoretically well-controlled exclusive N-jet cross section. Track based variables are very sensitive to the underlying events and soft radiation, therefore studies of these variables give valuable input for event generator developments. The measurements are performed for the events with pairs of muons produced in the decay of an on-shell Z boson with invariant mass between 76 and 106 GeV, and for the off-shell Z boson with invariant mass between 125 and 150 GeV, 150 and 350 GeV and 350 and 1500 GeV. Track based variables are also measured in four different Z boson transverse momentum regions. The measurements for on-shell Z bosons showed that the low zero-jettiness region in the inclusive case is best described by the GENEVA prediction. In the higher Z boson transverse momentum region, where we expect to have one or more jets accompanying the Z boson, among the predictions MADGRAPH5 aMC@NLO is doing best. For the higher invariant mass regions, all predictions show a fair agreement with the data. Measurements of these variables show a good potential for studies of the underlying events. By studying track based variables for the invariant mass above the Z peak, the regime similar to the Higgs boson has been explored.

Jet-based variables that have been measured are τ_{max} and τ_{sum}. These variables are defined using the jet transverse momentum weighted by a rapidity dependent function. Jet-based variables introduce a possibility to apply a tight veto on central jets while at forward rapidities the veto constrains get looser. The τ_{max} variable showed a good agreement with the predictions, especially

with MadGraph5_aMC@NLO. This variable can be used as a jet veto.

3 Final evaluation of the dissertation

3.1 Compliance with the explanation of the topic

Both themes of the thesis, the physics measurement, and the optimization of the detector performance, have been explored in detail. The work fully complies with the explanation of the topic.

3.2 Possibility of repeatability

The measurement has been performed using the CMS experiment data. It could be repeated using the data of the ATLAS experiment. It can also be repeated with both set of data by exploiting the electron-positron pair decay of the Z boson.

Nevertheless, the analysis is complex and will be difficult to reproduce by someone external to the CMS collaboration.

A numerical form of the results will be published in addition to the article in HEPDATA (https://www.hepdata.net/) and be included in the Robust Independent Validation of Experiment and Theory (Rivet, (https://rivet.hepforge.org/) to allow a comparison with any calculation.

3.3 Future research

The thesis aims to study new variables proposed to be used in place of jet vetoes in HEP data analyses. The work has shown that the modeling of N-jettiness variables by Monte-Carlo generators is worse than the modeling of jets. Therefore, it calls for research on improving the theoretical calculations, first in the view of their usage in data analysis, and second for a better understanding of the resummation of higher terms.

3.4 Dissertation limitations and their impact on the value of the dissertation

No particular limitations.

Orginal scientific contribution

(give clarification: originality (originality (completely new knowledge, addition / expansion of existing knowledge or refutation of existing knowledge), the impact of dissertation results on the progress of the scientific field, the impact of results on the profession (directly, indirectly))

This work contributes to the understanding and modeling of soft gluon radiation in proton-proton collisions. It provides measurements of variables introduced in 2010 and which have been recently used in cross-section calculations and brought them to an unprecedented accuracy, next-to-next-to-leading order (NNLO) in α_s combined to next-to-next-to-leading logs (NNLL) and parton shower. Calculations including parton shower are extremely important from the

experiment point of view because they allow the simulation of the proton-proton collisions including the response of the detector, which is not the case for fixed-order calculation. The simulation is essential in the design and the data exploitation of experiments like CMS. This variable has been measured so far only in the special case of N=0 (0-jettiness). This thesis is its first measurement for N≥1.
The contribution from the higher terms is higher in the case of the Higgs boson production. A similar resummation regime can be reached requiring an off-shell Z boson with a high Z mass. The Z boson, produced abundantly at the LHC, has been used as a proxy to understand the rare production of the Higgs boson and validate the cross section calculations. In addition, this variable can be exploited in the discrimination of the different production mechanisms of the Higgs bosons, which are characterized by several and different jets in the final state.
The ECAL detector provides detection and energy measurements of photons, electrons and positrons and is therefore a key component of CMS. To perform high precision measurements and searches an excellent performance of this detector is necessary.

Opinion and proposal of the commision

(give opinion and proposal)

The thesis presents the first measurements of the N-jettiness variables in the production of real and virtual Z boson events with the CMS detector and performance of its electromagnetic calorimeter.
Because of the good convergence of its cross section perturbative series, the production of a Z boson is an excellent playground to test resummation and confront the calculations with measurements. Resummation regimes similar to the Higgs boson can be reached requiring an off-shell Z boson with a high Z mass.
The electromagnetic calorimeter plays a crucial role within the CMS detector system and such good resolution achieved with the contribution of the work presented in this thesis is of vital interest for the scientific program of the collaboration.
Results of the dissertation have been shown at international conferences and CMS workshops. The results on the electromagnetic calorimeter have been published in the Journal of Instrumentation which is a leading journal in particle physics instrumentation.
Jelena Mijušković on behalf of the CMS collaboartion
„The CMS electromagnetic calorimeter upgrade: high-rate readout with precise time and energy resolution“,
Journal of Instrumentation (JINST) 2022 17 C01004

A publication of the measurements of the N-jettiness variables is in preparation. The analysis and the paper draft are currently under review within the CMS collaboration.
Having in mind all the above, the commission is pleased to propose to the Council of the Faculty of Natural Sciences and Mathematics of the University of Montenegro to accept the doctoral dissertation entitled "Measurement of the N-jettiness variables in the production of Z boson events with the CMS detector and performance of its electromagnetic calorimeter" of candidate Jelena Mijušković, as well as to propose to the Senate of the University of Montenegro, to appoint a commission for the defense of this doctoral dissertation.

Dissenting opinion

(fill in if a member of the commission has a dissenting opinion)

Ime i prezime

Remark	
(popuniti po potrebi)	
KOMISIJA ZA OCJENU DOKTORSKE DISERTACIJE	
Dr Marco Delmastro, research director, LAPP, Univerzitet Savoie Mont Blanc, CNRS/IN2P3, Annency, France	
Dr Ulla Blumenschein, senior lecturer, School of Physics and Astronomy, Queen Mary, University of London, England	
Dr Philippe Gras, researcher with permanent position, CEA-IRFU, Saclay, Paris, France	
Dr Federico Ferri, researcherer with the HDR (habilitation a diriger des recherches), CEA-IRFU, Saclay, Paris, France	
Dr Nataša Raičević, professor, University of Montenegro, Montenegro	
Datum i ovjera (pečat i potpis odgovorne osobe)	
Podgorica 30.05.2022. MP	DEKAN

Council of the Faculty of Science and Mathematics

Senate of the University of Montenegro

Referee's report of the PhD thesis

" Measurement of the N-jettiness variables in the production of Z boson events with the CMS detector and performance of its electromagnetic calorimeter "

written by PhD student Jelena Mijušković

The undersigned dr Ulla Blumenschein, senior lecturer at School of Physics and Astronomy, Queen Mary University of London, dr Marco Delmastro, research director at LAPP, Univerzitet Savoie Mont Blanc, LAPP, CNRS/IN2P3, Annecy, France, Dr Federico Ferri, researcher with habilitation (habilitation à diriger des recherches) at CEA- IRFU, Saclay, Paris, Dr Philippe Gras researcher with permanent position at CEA- IRFU, Saclay, Paris and Dr Nataša Raičević, professor at University of Montenegro, nominated with the Decision No. 03-222/1 from 9.03.2022 of the Senate of the University of Montenegro as members of the Committee for review and evaluation of the doctoral dissertation "Measurement of the N-jettiness variables in the production of Z boson events with the CMS detector and performance of its electromagnetic calorimeter " elaborated by the doctoral student Jelena Mijušković, present the following referee report.

The scientific area of the thesis is Elementary Particle Physics also called High Energy Physics. This thesis presents the measurements of the differential cross section of Z boson production in association with jets in proton-proton collisions at center of mass energy of 13 TeV. The analysed data has been collected by the CMS (Central Muon solenoid) experiment of LHC (Large Hadron Collider) during the year 2018 and corresponds to an integrated luminosity of 59 fb^{-1}. The main focus of the thesis is the measurement of N-jettiness variables, τ_N:

$$\tau_N = \sum_k \min\{q_a \cdot p_k, q_b \cdot p_k, q_1 \cdot p_k \cdots q_N \cdot p_k\}$$

where p_k is the four-momentum of particle k, q_a and q_b are the four-momenta of the beams and $q_1,\ldots,q_N$ represents the four-momenta of N jets in the event. For events with at least N jets, in the limit when $\tau_N \to 0$, the event contains N narrow jets.

In this thesis, the cross section is measured as a function of track-based event shape variables: zero-jettiness (τ_0), one-jettiness (τ_1) and the sum of the transverse momentum of particles.

Beside the track based variables, the so called jet based variables are also measured. These variables use jets reconstructed with the anti-k_T algorithm. Jet based variables, are defined via:

$$\tau_j = p_T^j \frac{1}{2\cosh(y_j - Y)},$$

where p_T^j and y_j are transversal momentum and rapidity of jet j and Y is Z boson rapidity. The cross section measurements depending on $\tau_{max} = \max_j \tau_j$ and $\tau_{sum} = \sum_j \tau_j$ are presented.

The measurements of event shape variables are performed for the events where pairs of muons are produced in the decay of a Z boson on-shell with an invariant mass between 76 and 106 GeV and also for off-shell Z bosons with an invariant mass between 125 and 150 GeV, 150 to 350 GeV and 350 and 1500 GeV and in four different Z boson transverse momentum regions.

The measurements have been compared with two theoretical predictions based on fixed-order parton-level cross sections calculated at LO or NLO accuracy in QCD for different ligh-parton multiplicities, merged and matched with parton shower. They have been computed with MadGraph5_aMC@NLO. The former merges multiplicities from zero to four at LO, and the latter from zero to two at NLO. The measurements are also compared with a predication at NNLO at fixed order combined with the resummation of higher-order terms in 0-jettiness and matched with parton shower obtained with the Geneva event generator.

Part of the thesis is devoted to the studies of the performance and the calibration of the Electromagnetic calorimeter (ECAL) of CMS during the Run 2 data taking period (2016, 2017 and 2018 years). This subdetector is crucial for the detection of photons, electrons and positrons and is therefore very important for many analyses in CMS.

This thesis consists of an introductory part, five chapters and a conclusion. The list of figures and tables are provided. The dissertation is preceded by an abstract written in Montenegrin, French and English. The theoretical introduction to the Standard Model is described in chapter 1. In chapter 2, the CMS detector is presented. Intercalibration and performance of ECAL is described in chapter 3. The measurements of track-based event shape variables are presented in chapter 4, and the measurements of jet-based event shape variables are presented in chapter 5. Summary and conclusions follows.

Chapter 1 describes the theoretical basis of the Standard Model. The theories and Lagrangians that describe fundamental interactions are briefly summarized: quantum electrodynamics, quantum chromodynamics and electroweak theory with electroweak symmetry breaking. Main concepts Beyond the Standard Model theory are discussed and conclude section 1.1 of this chapter. The theoretical treatment of the computation of the cross-section of proton-proton interactions, with collinear factorisation and Parton Density Functions are descried in section 1.2. After this general part, in section 1.3 Drell-Yan processes are explained in detail. The main diagrams, LO and NLO associated to them are discussed as well as higher order diagrams which include loops of quarks and gluons. With these additional terms the logarithms of the form $(\alpha_s \log Q^2/M^2)^n$ where n is the number of quark (gluon) loops and M the renormalization point of the strong coupling, α_s , are introduced. Also, additional radiation that can occur by quarks and leptons is explained.

The section 1.4 introduces Monte Carlo (MC) simulations which include physics processes and also the response of the detectors and have very important role for measurements and new discoveries. The main concepts of generators used in the comparison of data and theoretical predictions, MadGraph5_aMCc@NLO and Geneva are described.

Chapter 2 describes the experimental setup. Protons are accelerated in the Large Hadron Collider (LHC) and the particles produced in their collisions are detected with the CMS detector. CMS is a very sophisticated apparatus made of subdetectors using different technologies. By combining the information from the subdetectors, the complete kinematics of each collision is reconstructed: the produced particles are identified and their momenta and energies are measured. In this chapter, the accelerator system and the detector with its subsystems are presented. In section 2.1 a brief description of LHC, its design, performance, operation and future plans are given. Section 2.2 is devoted to the CMS experiment. The CMS coordinate system and the main the kinematic variables that describe particles created in proton-proton interactions are defined. The design and performance of the key components of CMS are briefly described: the superconducting solenoid, the tracker, the electromagnetic and hadronic calorimeters as well as the muon system. After this, the concept and logic of the trigger system is explained. The reconstruction of particles inside the detector is described in section 2.3. It explains track and vertex reconstruction, electron and photon reconstruction, muon reconstruction as well as the particle flow algorithm based on information from different detector systems. This chapter is concluded by section 2.4 in which the CMS upgrade for the phase of high luminosity (HL) is described.

As mentioned above, a part of the thesis is devoted to intercalibration and performance studies of the CMS electromagnetic calorimeter, which is described in **Chapter 3**. The excellent resolution of the CMS electromagnetic calorimeter plays an important role in many physics analyses performed at CMS. In particular, its precise measurement of the electron and photon energy had an essential contribution in the discovery of the Higgs boson through the $H \rightarrow \gamma\gamma$ channel during the LHC Run 1 period. In order to optimize the performance, a calibration of the relative response of the ECAL channels and corrections for the response variation in time are performed. The Run 2 data taking period, with the increased pileup and radiation level, created a challenging environment for ECAL.

The energy and signal reconstructions in the ECAL are described in sections 3.1 and 3.2. Since the response of the ECAL varies with time due to the crystal transparency variation induced by irradiation, constant calibration of the detector is performed. The laser monitoring system used for monitoring the crystal transparency is described in Section 3.3. A part of this PhD work was devoted to the intercalibration of the ECAL using the Drell-Yan process where electron-positron pairs are produced. The intercalibration constants were obtained for all three years of the Run 2 period. In addition, this thesis includes work on resolution studies for the Run 2 period and a comparison of the performance of ECAL during Run 1 and Run 2. In section 3.4 the different intercalibration methods are described while section 3.5 provides more detail on the one exploiting the Drell-Yan processes. The plans for the ECAL barrel readout electronics for the HL-LHC are described in Section 3.6.

In **Chapter 4**, the measurements of the differential cross section for the production of a Z boson as a function of track based event shape variables, τ_0 and τ_1, and as function of the sum of the transverse momentum of charged particles are presented. The Z bosons are selected by their decay channel into two muons. The measurement is done for both on- and off- shell bosons and includes also the contribution from γ^*. The event shape variables are computed with charged particles only in order to constrain the contributions coming from the pileup particles. The measurements are performed in four different transverse momentum, p_T (Z), regions and in three different dilepton mass (M_{ll}) regions. In the first part of this chapter (Section 4.1), the measured variables are defined. In Section 4.2, data samples and simulated samples are presented. The selection criteria for the events and for the particles used for the N-jettiness calculation are described in Section 4.3. The event selection is based on the identification of two muons with high quality tracks combined from the tracker and muon systems. Beside the track quality these muons are required to be well isolated from jets to exclude muons produced in hadron decays. In addition, it is required that one of the two muons has a transverse momentum above 25 GeV and the other above 20 GeV. Charged particles selected for the calculation of track-based variables are required to have a minimum transverse momentum of 1 GeV. Only particles within the tracker pseudorapidity full-precision acceptance, $|\eta| < 2.4$, are considered. The main challenge for these measurements is the presence in the recorded events of many overlaping proton-proton collisions, 35 on average, called pileup and occurring at the same time as the collision producing the Z boson because of the high luminosity of the colliding beams. To suppress the contribution from pileup, the selected particles are required to issue from the primary vertex of the interaction of interest.

The response of the detector is simulated in detail with a sophisticated software modeling the interaction of each particle with its material and emulating the readout electronics. The simulation is compared with the real data to measure any difference. The Section 4.4 describes the extraction of corrections which are then applied to further improve the accuracy of the simulation. These corrections are common to all the analyses performed with the CMS data. The calculation of the trigger scale factor was part of the thesis work and has been done using the *Tag-and-Probe* method, while the other corrections were computed by some other CMS collaborators. After the corrections were applied, the detector distributions of muon and muon pairs were compared with the simulation. The comparison was also done for the track variables. In order to compare the obtained results with the theoretical predictions or with the results from other experiments, the measurements have to be corrected for the detector effects such as object reconstruction, inefficiency inside the acceptance of the detector and the misidentification of the objects of interest. In addition, since the reconstruction system has a finite resolution, the measured value of an observable usually does not correspond to the true one. The techniques for the deconvolution of the detector effects are presented in Section 4.5. In section 4.6, the following systematic uncertainties were explained and calculated: pileup, luminosity, background, lepton energy scale, lepton energy resolution, lepton reconstruction and trigger efficiency, track momentum, track efficiency and unfolding method. This section also includes a detailed explanation of the theoretical prediction uncertainties. The measurements of track-based variables are shown in section 4.7. The measurements are performed for events with a Z boson with invariant mass between 76 and 106 GeV, corresponding to the peak region, 125 and 150 GeV, 150 and 350 GeV and 350 and 1500 GeV. Track-based variables are also measured in four

different Z boson transverse momentum regions: bellow 6 GeV, from 6 to 12 GeV, from 12 to 25 GeV and above 25 GeV. For all the cases, the detector level distributions are also shown. The measurements have been compared with the three theoretical predictions described in the introduction.

Chapter 5 contains the results of measurements of jet based event shape observables in the production of the Z boson in association with jets. These observables are measured in events with a Z boson in the mass peak region. The definitions of the jet based observables, τ_{max} and τ_{sum}, are presented in Section 5.1. The importance of the cross section measurement dependence on such variables and their advantages with respect to the jets selection according to their transverse momentum value is explained. Section 5.2 describes jet reconstruction and selection. Two methods of suppression of the pileup contribution from the jet reconstruction are compared and the one more appropriate for the N-jettiness measurements is adopted. Section 5.3 explains additional systematic uncertainties which arise due to the jet selection: the jet energy scale and jet energy resolution uncertainties. The results are presented in section 5.4 starting with results on all the uncertainties of the jet based variables. The detector level distributions comparison between data and Monte Carlo are shown. The results on the differential cross sections on jet based variables conclude this chapter. The experimental measurements are compared with the same theory calculations as used in chapter 4.

Finally, the results of the thesis are summarized in the **Conclusion**.

Conclusions

Differential cross sections have been measured as a function of track-based event shape variables and as a function of jet-based event shape variables. The measurements have been compared with two theoretical predictions based on fixed-order parton-level cross sections calculated at LO or NLO accuracy in QCD for different ligh-parton multiplicities, merged and matched with parton shower computed with MadGraph5_aMC@NLO, one merging multiplicities from zero to four at LO and the other from zero to two at NLO. They have also been compared with a predication at NNLO at fixed order combined with the resummation of higher-order terms in 0-jettiness and matched with parton shower obtained with GENEVA. Track-based variables that have been measured are the zero-jettiness, one-jettiness and the sum of the transverse momentum of charged particles. These variables can be used as a veto for hard radiation or jets and to define a theoretically well-controlled exclusive N-jet cross section. Track based variables are very sensitive to the underlying events and soft radiation, therefore studies of these variables give valuable input for event generator developments. The measurements are performed for the events with pairs of muons produced in the decay of an on-shell Z boson with invariant mass between 76 and 106 GeV, and for the off-shell Z boson with invariant mass between 125 and 150 GeV, 150 and 350 GeV and 350 and 1500 GeV. Track based variables are also measured in four different Z boson transverse momentum regions. The measurements for on-shell Z bosons showed that the low zero-jettiness region in the inclusive case is best described by the GENEVA prediction. In the higher Z boson transverse momentum region, where we expect to have one or more jets accompanying the Z boson, among the predictions MADGRAPH5 aMC@NLO is

doing best. For the higher invariant mass regions, all predictions show a fair agreement with the data. Measurements of these variables show a good potential for studies of the underlying events. By studying track based variables for the invariant mass above the Z peak, the regime similar to the Higgs boson has been explored. Jet-based variables that have been measured are τ_{max} and τ_{sum}. These variables are defined using the jet transverse momentum weighted by a rapidity dependent function. Jet-based variables introduce a possibility to apply a tight veto on central jets while at forward rapidities the veto constrain gets looser. The τ_{max} variable showed a good agreement with the predictions, especially with MadGraph5_aMC@NLO. This variable can be used as a jet veto.

Opinion and proposal of the commision

The thesis presents the first measurements of the N-jettiness variables in the production of real and virtual Z boson events with the CMS detector and performance of its electromagnetic calorimeter.

Because of the good convergence of its cross section perturbative series, the production of a Z boson is an excellent playground to test resummation and confront the calculations with measurements. Resummation regimes similar to the Higgs boson can be reached requiring an off-shell Z boson with a high Z mass.

The electromagnetic calorimeter plays a crucial role within the CMS detector system and such good resolution achieved with the contribution of the work presented in this thesis is of vital interest for the scientific program of the collaboration.

Results of the dissertation have been shown at international conferences and CMS workshops. The results on the electromagnetic calorimeter have been published in the Journal of Instrumentation which is a leading journal in particle physics instrumentation.

Jelena Mijušković on behalf of the CMS collaboartion
„The CMS electromagnetic calorimeter upgrade: high-rate readout with precise time and energy resolution",
Journal of Instrumentation (JINST) 2022 17 C01004

A publication of the measurements of the N-jettiness variables is in preparation. The analysis and the paper draft are currently under review within the CMS collaboration.

Having in mind all the above, the commission is pleased to propose to the Council of the Faculty of Natural Sciences and Mathematics of the University of Montenegro to accept the doctoral dissertation entitled "Measurement of the N-jettiness variables in the production of Z boson events with the CMS detector and performance of its electromagnetic calorimeter" of candidate Jelena Mijušković, as well as to propose to the Senate of the University of Montenegro, to appoint a commission for the defense of this doctoral dissertation.

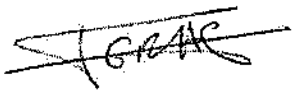
28.3.2022.

Committee for review and evaluation of the doctoral dissertation

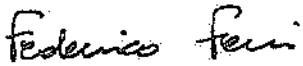
Dr Ulla Blumenschein

Dr Marco Delmastro

Dr Philippe Gras



Dr Federico Ferri



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UNIVERZITET CRNE GORE

PRIRODNO-MATEMATIČKI FAKULTET

N/r dekanu

Prof. dr Predrag Miranović

Poštovani profesore Miranoviću,

U prilogu ovog akta dostavljamo Vam doktorsku disertaciju mr **Jelene Mijušković** pod naslovom **"Mjerenje N – džetnosti varijabli u događajima sa produkcijom Z bozona u CMS detektoru i performanse njegovog elektromagnetnog kalorimetra"** i Izvještaj o ocjeni doktorske disertacije koji su u skladu sa članom 42 stav 3 Pravila doktorskih studija dostavljeni **Centralnoj univerzitetskoj biblioteci** 30. 03. 2022. godine, na uvid i ocjenu javnosti.

Na navedeni rad nije bilo primjedbi javnosti u predviđenom roku od 30 dana.

Molimo Vas da nam nakon odbrane dostavite konačnu verziju doktorske disertacije.

S poštovanjem,

UNIVERZITET CRNE GORE UCG 1

DIREKTOR

mr Bosiljka Cicmil

Pripremila:

Milica Barac
Administrativna asistentkinja
Tel: 020 414 245
e-mail: cub@ucg.ac.me

Angelina Šofranac

Jevgenij Čičvarkin, telekomunikacioni tajkun koji je 2008. pobjegao iz Rusije i postao ugledni londonski ugostitelj, odavno otvoreno podržava Ukrajinu.

Ovaj multimilioner kaže da je sa suprugom Tatjanom Fokinom od početka ruske invazije 24. februara poslao četiri kamiona medicinske i zaštitne opreme u Poljsku da pomogne Ukrajincima, piše Rojters. Čičvarkin je rekao da je sam prevezao prvu isporuku.

Međutim, 48-godišnji preduzimač i dugogodišnji kritičar ruskog predsjednika Vladimira Putina, kaže da je jedan od njegovih računa u švajcarskoj banci neočekivano zamrznut. Odbio je da kaže koja banka je u pitanju.

Čičvarkin je jedan od sve većeg broja Rusa koji žive u inostranstvu i imaju problema da pristupe svom novcu, čak i ako nisu direktna meta sankcija Zapada.

Sankcije čiji je cilj da kazne ljude iz Putinovog užeg kruga takođe pogađaju vlasnike ruskih pasoša, piše u Rojtersovoj analizi.

Četiri Rusa koji žive u inostranstvu sa dvojnim državljanstvom ispričali su da su im blokirani računi ili plaćanja u Londonu, Cirihu i Parizu. Jedan bogati emigrant u Londonu rekao je da je prešao na gotovinu da bi kupovao i da se pritajio.

Dva savjetnika i jedan advokat su kazali da se odbijaju zahtjevi ruskih klijenata za otvaranje bankovnih računa. Banke su saopštile da preduzimaju dodatne mjere opreza sa ruskim novcem. A tri brokera su izjavila da su stopirani neki poslovi sa nekretninama i umjetničkim djelima.

Jedan kanadsko-američki advokat je rekao da se ruski klijenti plaše da putuju u inostranstvo da ih ne bi zaustavili na carini jer zapadne banke dovode u sumnju sav ruski novac - čak i donacije humanitarnim organizacijama. Dvostruko državljanstvo više ne pruža bezbjedan izlaz kao nekad.

"Neki Rusi ne mogu da izađu iz hotela, studenti nemaju novca jer su im kreditne kartice bezvrijedne", rekao je Bob Amsterdam iz advokatske firme Amsterdam & Partners.

"MORATE BITI VRLO TIH"

Nekoliko advokata koji zastupaju bogate Ruse u Evropi govorili su o svepristunoj atmosferi nepovjerenja. Jedna ekspertkinja za finansijsko planiranje, koja je željela da ostane anonimna zbog, kako je rekla, atmosfere kažnjavanja povezanosti sa Rusijom, rekla je da Ruse provjeravaju bez obzira na mjesto stanovanja ili bogatstvo.

"Trenutno, sve što je rusko je toksično, što znači da svi pokušavaju da budu ekstremno, ekstremno oprezni prema ruskim klijentima", rekao je advokat sa ruskim i britanskim državljanstvom, koji ima advokatsku firmu u Cirihu.

Novinarka Elena Servetaz, koja ima dvostruko državljanstvo i živi u Francuskoj od 2005, rekla je da je francuska banka Crédit Mutuel odbila transfer manje od hiljadu eura na njen račun - novac koji joj je poslat iz Londona za humanitarnu pomoć ukrajinskim izbjeglicama.

Iz banke su joj rekli da je transakcija označena ka sporna zbog njene ruske nacionalnosti. Ona je dobila novac nakon duže od 7 dana.

"Tako je nepošteno, kada ste dio ruske opozicije, pomažete ukrajinskim izbjeglicama, da vam kažu da ne možete da dobijete svoj novac zato što ste Rus", kazala je za Rojters.

Banka Crédit Mutuel je saopštila da su evropske banke u obavezi da sa "najvećim oprezom" kontrolišu transakcije koje mogu biti obuhvaćene sankcijama EU i da dodatne provjere mogu dovesti do kašnjenja, iako daje sve od sebe da ograniči

„Trenut

Na osnovu člana 32 stav 1 tačka 14 Statuta Univerziteta Crne Gore, u vezi sa članom 41 Pravila doktorskih studija, Senat Univerziteta Crne Gore, u postupku razmatranja predloga Vijeća Prirodno-matematičkog fakulteta i utvrđivanja ispunjenosti uslova iz Pravila doktorskih studija za ocjenu doktorske disertacije i dalji rad na disertaciji mr Jelene Mijušković, na predlog Odbora za doktorske studije, na sjednici održanoj 09.03.2022. godine, donio je sljedeću

O D L U K U

I

Utvrđuje se da su ispunjeni uslovi iz člana 38 Pravila doktorskih studija za ocjenu doktorske teze i dalji rad na disertaciji „Mjerenje N-džetnosti varijabli u događajima sa produkcijom Z bozona u CMS detektoru i performanse njegovog elektromagnetnog kalorimetra" kandidatkinje mr Jelene Mijušković.

II

Imenuje se Komisija za ocjenu navedene doktorske disertacije, u sastavu:

1. Dr Nataša Raičević, redovni profesor Prirodno-matematičkog fakulteta Univerziteta Crne Gore,
2. Dr Federiko Ferri, istraživač Instituta CEA-IRFU, Saclay, Pariz
3. Dr Marco Delmastro, istraživač Univerziteta Savoie Mont Blanc, Annecy, Francuska
4. Dr Ula Blumenschein, senior predavač u Školi fizike i astronomije, Queen Mary Univerziteta London, Velika Britanija
5. Dr Philippe Gras, istraživač Instituta CEA-IRFU, Saclay, Pariz

III

Zadatak Komisije je da, u roku od 60 dana od dana dostavljanja odluke podnese Vijeću Prirodno-matematičkog fakulteta i Senatu izvještaj o ocjeni navedene doktorske disertacije.

IV

Odluka stupa na snagu danom donošenja.

Broj: 03- 222/1
Podgorica, 09.03.2022. godine

UNIVERZITET CRNE GORE 1974

PREDSJEDNIK SENATA

Prof. dr Vladimir Božović, rector

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Датум, 28.10.2010. г.

УНИВЕРЗИТЕТ ЦРНЕ ГОРЕ
Природно-математички факултет
Број 2948
Подгорица 11.11.2010 год.

Ref:
Date,

Na osnovu člana 75 stav 2 Zakona o visokom obrazovanju (Sl.list RCG, br. 60/03 i Sl.list CG, br. 45/10) i člana 18 Statuta Univerziteta Crne Gore, Senat Univerziteta Crne Gore, na sjednici održanoj 28.10.2010. godine, donio je

ODLUKU
O IZBORU U ZVANJE

Dr NATAŠA RAIČEVIĆ bira se u akademsko zvanje **redovni profesor** Univerziteta Crne Gore za predmete: Elektromagnetizam i Fizika elementarnih čestica, na **Prirodno-matematičkom fakultetu.**

REKTOR

Prof.dr Predrag Miranović

Curriculum Vitae

Lični podaci

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Datum i mjesto rođenja: 12.08. 1970, Srbija

Djevojačko prezime: Saveljić

Strani jezici: engleski – aktivno znanje
ruski – dobro razumijevanje i čitanje

Kontakt

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Obrazovanje

1993 **Diplomirani fizičar**, Univerzitet Crne Gore, Prirodno-matematički fakultet (prosječna ocjena na studijama 9.90)

1997 **Magistar fizičkih nauka**, Univerzitet u Beogradu, Fizički fakultet (prosječna ocjena na studijama 10.0)

2000 **Doktor fizičkih nauka**, Univerzitet u Beogradu, Fizički fakultet

Studentske nagrade i priznanja

1990 Decembarska nagrada za najboljeg studenta Prirodno-matematičkog fakulteta

1993 Nagrada Univerziteta Crne Gore za najboljeg studenta završne godine Prirodno-matematičkog fakulteta Univerziteta Crne Gore za školsku 1992/93. godinu

Profesionalne pozicije

1993–1997 **Saradnik u nastavi** na Prirodno-matematičkom fakultetu Univerziteta Crne Gore u Podgorici, Crna Gora

1997–2000 **Asistent** na Prirodno-matematičkom fakultetu Univerziteta Crne Gore u Podgorici,

Crna Gora

2000–2005 **Docent** na Prirodno-matematičkom fakultetu Univerziteta Crne Gore u Podgorici, Crna Gora

2005–2010 **Vanredni profesor** na Prirodno-matematičkom fakultetu Univerziteta Crne Gore u Podgorici, Crna Gora

2010–danas **Redovni profesor** na Prirodno-matematičkom fakultetu Univerziteta Crne Gore u Podgorici, Crna Gora

Nastava

Vježbe na matičnom i nematičnim fakultetima (u zvanju saradnika i asistenta)

Elektromagnetizam, Optika, Statistička fizika, Fizika čvrstog stanja, Nuklearna fizika (PMF), Eksperimentalne vježbe na nematičnim fakultetima

Predavanja na predmetima (u zvanju docenta, vanrednog i redovnog profesora)

Elektromagnetizam – osnovne studije na Prirodno-matematičkom fakultetu

Fizika elementarnih čestica – specijalističke studije na Prirodno-matematičkom fakultetu

Računari i programiranje – osnovne studije na Prirodno-matematičkom fakultetu
Teorijska elektrodinamika - osnovne studije na Prirodno-matematičkom fakultetu

Viši kurs fizike elementarnih cestica 1 - magistarske studije na Prirodno-matematičkom fakultetu

Eksperiment u savremenoj fizici čestica - magistarske studije na Prirodno-matematičkom fakultetu
Viši kurs fizike elementarnih čestica - magistarske studije na Prirodno-matematičkom fakultetu
Biofizika na Medicinskom fakultetu

Poglavlja iz fizike u okviru predmeta Fiziologija na Medicinskom fakultetu

Oblast istraživanja

Eksperimentalna fizika elementarnih čestica

1995 – 1999 Član međunarodne istraživačke kolaboracije eksperimenta CERES u laboratoriji CERN u Ženevi (akcelerator SPS)

1995–1996 Testiranje performansi trigera prvog nivoa na eksperimentu CERES
Ujedinjeni institut za nuklearna istraživanja u Dubni, Rusija

1996-1997 Unapređenje softvera za analizu događaja sa eksperimenta CERES – rekonstrukcija verteksa za interakciju jezgara olova sa segmentisanom metom od zlata
Ujedinjeni institut za nuklearna istraživanja u Dubni, Rusija

1996–1999 Proučavanje emisije e^+e^- parova u interakcijama teških jona
Fizički institut Univerziteta u Hajdelbergu, Njemačka
Univerzitet Crne Gore

2002– Član međunarodne istraživačke kolaboracije eksperimenta H1 u laboratoriji DESY u Hamburgu, Njemačka (akcelerator HERA)
Ova istraživanja realizovana su na Univerzitetu Crne Gore i kroz veći broj višemjesečnih boravaka godišnje na institutu DESY u Hamburgu i Berlinu.

2002-2005 Analiza podatataka za mjerenje efikasnog presjeka za duboko neelastično rasijanje elektrona (pozitrona) na protonu pri malim i srednjim vrijednostima kvadrata predatog kvadri-impulsa

2004-2005 Rad na unapređenju softverskog rješenja za simulaciju kaskada čestica u kalorimetru H1 eksperimenta koji detektuje elektrone sa malim uglom rasijanja.

2005-2007 Analiza podatataka za mjerenje efikasnog presjeka za duboko neelastično rasijanje elektrona (pozitrona) na protonu pri velikim vrijednostima neelastičnosti interakcije

2006-2007 Učešće u priprema seansi za e^+p interakcije sa redukovanim energijama protona sa HERA akceleratora (kroz analizu tada postojećih eksperimentalnih podataka)

2007-2011 Mjerenje longitudinalne strukturne funkcije protona

2017- Član međunarodne istraživačke kolaboracije eksperimenta CMS u laboratoriji CERN u Ženevi, Švajcarska (akcelerator LHC)

2017 – Analiza produkcije Drell-Yan parova u proton-proton interakcijama.

Projekti (sa rukovodećom ulogom)

2004–2007 Učesnik na međunarodnom projektu finansiranom od strane DFG-a (Deutsche Forchungsgemeinschaft): **„Präzisionsmessungen und Analyse der Elektron-Quark-Wechselwirkung bei höchsten Energien sowie suche nach Phänomenen außerhalb des Standardmodels"**, broj **GZ:436JUG113/3/0-1**, odobren 2007. godine (partnerske strane: Univerzitet Crne Gore, institut DESY u Hamburgu, institut DESY-Zeuthenu u Berlinu i institut Max Planck u Minhenu).

2007–2010 Produžetak prethodnog projekta od DFG, pod brojem **GZ:436JUG113/3/0-2**

2005–2007 Rukovodilac naučno-istraživačkog projekta odobrenog od Ministarstva prosvjete i nauke Crne Gore **„H1 eksperiment na HERA akceleratoru"**

2008–2011 - Rukovodilac naučno-istraživačkog projekta odobrenog od Ministarstva prosvjete i nauke Crne Gore **„Duboko neelastično rasijanje elektrona (pozitrona) na protonu"**

2012-2015 - Rukovodilac naučno-istraživačkog projekta odobrenog od Ministarstva nauke Crne Gore **„Završna faza analiza H1 kolaboracije"**.

2019 – 2023 – Ključni partner u projektu odobrenog u program **HORIZONT2020 „The strong interaction at the frontier of knowledge: fundamental research and applications".**

Učešće u radu upravljačkih struktura velikih kolaboracija

2004–2012 učešće u radu Upravnog odbora H1 kolaboracije koji donosi najvažnije odluke za kolaboraciju

2007–2009 član Izvršnog odbora H1 kolaboracije

2012-2014 član Upravnog odbora H1 kolaboracije

2017- član Upravnog odbora CMS kolaboracije

Učešće u radu tijela/centara čiji je rad povezan sa obrazovanjem

2015-2017 – član Nacionalnog savjeta za obrazovnje Crne Gore

2015-2017 – član Odbora za obrazovnje Crne Gore

Od 2015 – član Centra za studije i kontrolu kvaliteta Univerziteta Crne Gore

Od 2015 – član Odbora za monitoring magistarskih studija Univerziteta Crne Gore

Od 2016 – član Vijeća za prirodne i tehničke nauke Univerziteta Crne Gore

Informatička pismenost

Operativni sistemi: UNIX i WINDOWS

Programski jezici: fortan, C, python

Nataša Raičević

Bibliografija

Odabrani radovi

1. N. Raičević, Fast simulation of electromagnetic and hadronic showers in SpaCal calorimeter at the H1 experiment, AIP Conf.Proc. 1722 (2016) 210003. **

2. H1 and ZEUS Collaborations (H. Abramowicz,..N. Raičević *et al.*),Combination of measurements of inclusive deep inelastic $e^{\pm}p$ scattering cross sections and QCD analysis of HERA data, Eur.Phys.J. C75 (2015) no.12, 580.

3. N. Raičević, Recent Results from HERA on the Proton Structure, Acta Phys.Polon.Supp. 7 (2014) 3, 439. **

4. N. Raičević, Precision Tests of QCD at HERA, Acta Phys.Polon.Supp. 6 (2013) 3, 985. **

5. N. Raičević, A. Glazov and A. Zhokin, Shower library technique for fast simulation of showers in calorimeters of the H1 experiment., Nucl.Instrum.Meth. A718 (2013) 104.

6. N. Raičević, Measurement of the diffractive DIS cross section at the H1 experiment, Rom. Rep. Phys. 65 (2013) 427. **

7. N. Raičević, Precision measurement of the proton structure at HERA, Rom.Rep. Phys. 65 (2013) 103. **

8. H1 Collaboration (F. D. Aaron,..N. Raičević *et al.*), Measurement of the Inclusive ep Scattering Cross Section at High Inelasticity y and of the Structure Function FL, Eur. Phys. J. C71 (2011) 1579.

9. A. Glazov, N. Raičević and A. Zhokin, Fast simulation of showers in the H1 calorimeter, Comput. Phys. Commun. 181 (2010) 1008.

10. N. Raičević, Measurements at high Q^2 and searches at the ep energy frontier, Nucl. Phys.

Proc. Suppl. 207-208 (2010) 125. **

11. N. Raičević, HERA results and their impact for LHC, Nucl. Phys. Proc. Suppl. 198: (2010) 75. **

12. N. Raičević, Measurement of proton structure and parton density functions from HERA, AIP Con. Proc. 1203 (2010) 85. **

13. N. Raičević, Measurement of the proton structure function $F_L(x, Q^{**}2)$ with the H1 experiment, AIP Con. Proc. 1203 (2010) 79. **

14. H1 Collaboration (F. D. Aaron,..N. Raičević *et al.*), A Precision Measurement of the Inclusive ep Scattering Cross Section at HERA, Eur. Phys. J. C64 (2009) 561,

15. N. Raičević, Proton structure and QCD dynamics at low x, Nucl. Phys. Proc. Suppl. 181-182 (2008) 57. **

16. N. Raičević, Measurement of the neutral current DIS cross section at H1, J. Phys. Con. Ser. 110 (2008) 022042. **

17. H1 Collaboration (F. D. Aaron,..N. Raičević *et al.*), Measurement of the Proton Structure Function $F_L(x, Q^2)$ at Low x, Phys. Lett. B665 (2008) 139.

18. N. Raičević, Measurement of the longitudinal structure function from e p collisions with the H1 detector at HERA, AIP Con. Proc. 899 (2007) 575. **

19. N. Raičević, Measurement of the inclusive e p deep inelastic scattering cross section at low Q^2 with the H1 detector at HERA, AIP Con. Proc. 899 (2007) 217. **

20. CERES/NA45 Collaboration (G. Agakichiev,..N. Saveljić et al.), e+e- pair production in Pb-Au collisions at 158-GeV per nucleon, Eur. Phys. J. C41 (2005) 475.

21. CERES/NA45 Collaboration (G. Agakichiev,..N. Saveljić et al.), Recent results from Pb - Au collisions at 158-GeV/c per nucleon obtained with the CERES spectrometer, Nucl. Phys. A 661 (1999) 23.

22. CERES/NA45 Collaboration (G. Agakichiev,..N. Saveljić et al.), CERES results on low mass electron pair production in Pb Au collisions, Nucl.Phys.A638 (1998) 159.

23. G. Agakishiev,.. ,..N. Saveljić *et al.*, A New robust fitting algorithm for vertex reconstruction in the CERES experiment, Nucl. Instrum. Meth. A 394 (1997) 225.

Odabrani radovi u zbornicima međunarodnih konferencija

24. N. Raičević, High y DIS cross section measurement with H1, Procedings of 15th International Workshop on Deep-Inelastic Scattering and Related Subjects, Munich, Germany, April 2007, vol. 1, 293, editors: G. Grindhammer, K. Sachs. ISBN 978-3-935702-23-2. **

25. N. Raičević, Structure functions and extractions of PDFs at HERA, Proceedings of 41st Rencontres de Moriond: QCD and Hadronic Interactions, La Thuile, Italy, 18-25 March 2006, 181, editors: Etienne Augé and Jean Tran Thanh. e-Print: hep-ex/0605050. **

** Radi se o publikacijama koje obuhvataju najzapaženije rezultate kolaboracija koji su predstavljani na međunarodnim konferencijama, a koje je N. Raičević predstavljala u ime jedne ili više kolaboracija.

Svi navedeni kolaboracioni radovi su radovi sa preko 100 citata tzv. **TOPCITE:100+** u bazama podataka.

Kompletna lista od oko 140 referentnih radova u kojima je N. Raičević autor ili koautor nalazi se u bazi podataka na web-stranicama

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R É P U B L I Q U E F R A N Ç A I S E

Ministère de l'enseignement supérieur, de la recherche et de l'innovation

SORBONNE UNIVERSITÉ

HABILITATION À DIRIGER DES RECHERCHES

Vu le code de l'éducation, et notamment son article L.613-1 ;

Vu les pièces justificatives produites par M. FEDERICO FERRI, né le 15 novembre 1978 à MILAN (ITALIE) en vue de son inscription pour le diplôme d'habilitation à diriger des recherches ;

Vu le procès-verbal du jury attestant que l'intéressé a présenté ses travaux le 4 octobre 2021 devant un jury présidé par BERTRAND LAFORGE et composé de FRANCO BEDESCHI, LOUIS FAYARD, MARCO PIERI, PARASKEVAS SPHICAS, ALESSANDRA TONAZZO ;

Vu la délibération du jury ;

Le diplôme d'HABILITATION À DIRIGER DES RECHERCHES en PHYSIQUE

est délivré à M. FEDERICO FERRI

pour en jouir avec les droits et prérogatives qui y sont attachés.

Fait le 10 novembre 2021

Le titulaire

L'administrateur provisoire

Dominique PATERON

Le Recteur d'Académie,
Chancelier des universités

Christophe KERRERO

N° SORBONU 14524872
/2021202004865

Federico Ferri ~ Curriculum Vitae et Studiorum

Personal details: born 15.11.1978 in Milano, Italy; italian nationality
Contact: federico.ferri@cern.ch

Career

2021 **Scientific Associate** at CERN
2008- **Staff** researcher at CEA Saclay, IRFU/DPhP
2007-2008 **Post-doctoral** researcher at CEA Saclay IRFU/DPhP
2005-2007 **Post-doctoral** researcher at Istituto Nazionale di Fisica Nucleare (INFN), Italy
2002-2005 **Ph.D.** in Physics and Astronomy, at the École Polytechnique Palaiseau and at the University of Milano-Bicocca. Thesis: "The CMS Electromagnetic Calorimeter for the Higgs Boson Search $H \to ZZ^{(*)} \to 4e$ at the LHC" (supervisors: T. Tabarelli de Fatis, Y. Sirois)
2002 **Fellow** researcher at Istituto Nazionale di Fisica Nucleare (4th in national-ranked admission)
2002 **Laurea** in Physics at the University of Milano–Bicocca, mark of 110/110 *cum laude*

Research highlights

Physics analyses

- **Discovery of the Higgs boson** with the CMS detector, in the diphoton decay channel
- Observation of **associated production of the Higgs boson with top quarks**
- Measurement of the **Higgs boson couplings, fiducial and differential production cross sections** with the diphoton decay channel - **Editor of** JHEP 1901(2019)183
- Measurement of the **Higgs boson mass** in the diphoton decay channel
- **Measurement** of the production cross section of pair of isolated photons in CMS
- **Study** and optimization of the electron and photon reconstruction in CMS

Detector performance

- **Construction, commissioning, calibration,** and **performance** optimization of the **CMS ECAL** (electromagnetic calorimeter), from the installation in CMS to physics with collisions
- Preparation of the **upgrade of the CMS ECAL** for the High-Luminosity LHC, consisting in the replacement of the front-end and back-end electronics
- Study of **radiation-induced effects in $PbWO_4$** scintillating crystals
- Calibration and performance of the **HARP Time-of-Flight system**
- Development and characterization of **glass-made Resistive Plate Chambers**

Roles and responsibilities within the CMS experiment

2019- *System Manager* of the CMS ECAL
2017-2019 *Deputy System Manager* of the CMS ECAL
2015-2016 *Convener* of the analysis group of the Higgs boson decaying into two photons
2013-2014 *Convener* of the Detector Performance Group of the CMS ECAL
2011-2012 *Responsible* of the CMS ECAL calibration
2011-2014 *Responsible* of the CMS ECAL laser monitoring system
2007-2010 *Responsable* of the CMS ECAL reconstruction software
2017- *Member* of the CMS Management Board
2013- *Member* of the CMS ECAL Editorial Board
2013- *Member* of the CMS ECAL Conference Committee

Publications

More than 1000 publications in international peer-reviewed journals, of which more than 20 among the primary contributors. Full up-to-date list available online.

PUBLICATIONS WITH MAIN CONTRIBUTIONS

[1] CMS Collaboration, "Observation of a New Boson at a Mass of 125 GeV with the CMS Experiment at the LHC," *Phys. Lett. B*, vol. 716, pp. 30–61, 2012.

[2] CMS Collaboration, "Observation of a New Boson with Mass Near 125 GeV in *pp* Collisions at $\sqrt{s} = 7$ and 8 TeV," *JHEP*, vol. 06, p. 081, 2013.

[3] CMS Collaboration, "Observation of the Diphoton Decay of the Higgs Boson and Measurement of Its Properties," *Eur. Phys. J. C*, vol. 74, no. 10, p. 3076, 2014.

[4] CMS Collaboration, "Measurements of Higgs boson properties in the diphoton decay channel in proton-proton collisions at $\sqrt{s} = 13$ TeV," *JHEP*, vol. 11, p. 185, 2018.

[5] CMS Collaboration, "Measurement of inclusive and differential Higgs boson production cross sections in the diphoton decay channel in proton-proton collisions at $\sqrt{s} = 13$ TeV," *JHEP*, vol. 01, p. 183, 2019.

[6] CMS Collaboration, "Performance of Photon Reconstruction and Identification with the CMS Detector in Proton-Proton Collisions at sqrt(s) = 8 TeV," *JINST*, vol. 10, no. 08, p. P08010, 2015.

[7] CMS Collaboration, "Performance of Electron Reconstruction and Selection with the CMS Detector in Proton-Proton Collisions at $\sqrt{s} = 8$ TeV," *JINST*, vol. 10, no. 06, p. P06005, 2015.

[8] CMS Collaboration, "Observation of $t\bar{t}H$ production," *Phys. Rev. Lett.*, vol. 120, no. 23, p. 231801, 2018.

[9] CMS Collaboration, "Measurement of the Production Cross Section for Pairs of Isolated Photons in *pp* collisions at $\sqrt{s} = 7$ TeV," *JHEP*, vol. 01, p. 133, 2012.

[10] CMS Collaboration, "Search for a standard model-like Higgs boson in the mass range between 70 and 110 GeV in the diphoton final state in proton-proton collisions at $\sqrt{s} = 8$ and 13 TeV," *Phys. Lett. B*, vol. 793, pp. 320–347, 2019.

[11] CMS Collaboration, "Time Reconstruction and Performance of the CMS Electromagnetic Calorimeter," *JINST*, vol. 5, p. T03011, 2010.

[12] CMS Collaboration, "Radiation hardness qualification of PbWO(4) scintillation crystals for the CMS Electromagnetic Calorimeter," *JINST*, vol. 5, p. P03010, 2010.

[13] P. Adzic *et al.*, "Intercalibration of the barrel electromagnetic calorimeter of the CMS experiment at start-up," *JINST*, vol. 3, p. P10007, 2008.

[14] CMS Collaboration, "The CMS Experiment at the CERN LHC," *JINST*, vol. 3, p. S08004, 2008.

[15] CMS Collaboration, "CMS technical design report, volume II: Physics performance," *J. Phys. G*, vol. 34, no. 6, pp. 995–1579, 2007.

[16] P. Adzic *et al.*, "Energy resolution of the barrel of the CMS electromagnetic calorimeter," *JINST*, vol. 2, p. P04004, 2007.

[17] CMS Collaboration, "Results of the first performance tests of the CMS electromagnetic calorimeter," *Eur. Phys. J. C*, vol. 44S1, pp. 1–10, 2006.

[18] P. Adzic *et al.*, "Reconstruction of the signal amplitude of the CMS electromagnetic calorimeter," *Eur. Phys. J. C*, vol. 46S1, pp. 23–35, 2006.

[19] S. Baffioni, C. Charlot, F. Ferri, N. Godinovic, P. Meridiani, I. Puljak, R. Salerno, and Y. Sirois, "Discovery potential for the SM Higgs boson in the H —> Z Z(*) —> e+ e- e+ e- decay channel," *J. Phys. G*, vol. 34, pp. N23–N46, 2007.

[20] S. Baffioni, C. Charlot, F. Ferri, D. Futyan, P. Meridiani, I. Puljak, C. Rovelli, R. Salerno, and Y. Sirois, "Electron reconstruction in CMS," *Eur. Phys. J. C*, vol. 49, pp. 1099–1116, 2007.

[21] A. Calcaterra *et al.*, "Analysis and interpretation of the performance degradation of glass Resistive Plate Chambers operated in streamer mode," *JINST*, vol. 2, p. P10003, 2007.

[22] HARP Collaboration, "The HARP detector at the CERN PS," *Nucl. Instrum. Meth. A*, vol. 571, pp. 527–561, 2007.

[23] HARP Collaboration, "Measurement of the production cross-section of positive pions in p-Al collisions at 12.9-GeV/c," *Nucl. Phys. B*, vol. 732, pp. 1–45, 2006.

[24] M. Baldo-Ceolin *et al.*, "The time-of-flight TOFW detector of the HARP experiment: Construction and performance," *Nucl. Instrum. Meth. A*, vol. 532, pp. 548–561, 2004.

[25] M. Bonesini *et al.*, "Laser-based calibration for the HARP time of flight system," *IEEE Trans. Nucl. Sci.*, vol. 50, pp. 1053–1058, 2003.

Conferences with published proceedings

1. The CMS ECAL Phase-2 Upgrade for High Precision Timing and Energy Measurements, VCI2019: 15th Vienna Conference on Instrumentation, 18-22 Feb 2019, Vienna (Austria)

2. Role of the CMS electromagnetic calorimeter in the measurement of the Higgs boson properties and search for new physics, ICHEP 2014: 37th International Conference on High Energy Physics, 2-9 Jul 2014, Valencia (Spain)

3. Monitoring and Correcting for Response Changes in the CMS Lead-tungstate Electromagnetic Calorimete, CALOR 2012: 15th International Conference on Calorimetry in High Energy Physics, 4-8 Jun 2012, Texas Tech University, Santa Fe, NM (United States)

4. Monitoring the stability of the CMS electromagnetic calorimeter, CALOR2010: 14th International Conference for Calorimetry in High Energy Physics, 10-14 May 2010, IHEP, Beijing (China)

Direct supervision experience

1. Post-doctoral supervision of Chiara Amendola, for the work on timing reconstruction and calibration for the ECAL Phase2 upgrade, 2020-(2022)

   The work consists in the study of the timing reconstruction for electrons and photons for HL-LHC. This implies the improvement of the current performance, understanding of its limitations, and plans for the upgraded electronics for HL-LHC, in terms of reconstruction and calibration methods. Also, the timing information will be fully integrated in the simulation of the CMS detector.

2. Ph.D. supervision of Giulia Negro, "Search for heavy neutrinos with the CMS experiment and studies for the upgrade of its electromagnetic calorimeter", 2015-2018

   Heavy neutrinos, produced in the decay of a right-handed W boson, were searched in a fully reconstructed final state containing two same flavour leptons and two jets, with data from 2016 collisions (35.9 fb^{-1}). Limits were set, becoming the most stringent result at the time of the publication. The analysis work done for 50% in collaboration with another (small) group and for 50% completely alone. The thesis also comprised the supervision and participation of beam test studies for the Phase2 electronics prototypes.

3. Ph.D. supervision of Laurent Millisher, "Measurement of the inclusive production cross section of prompt photon pairs with the CMS detector at the LHC", 2008-2011

   Events with two isolated photons have been analyzed from the early collisions of the LHC (7 TeV, 36 pb^{-1}. An important cross-section measurement preparatory to the search for the Higgs boson in its two photon decay. Comparison with several theoretical predictions have also been performed, providing useful input for theoreticians.

4. Supervision of the M2 stage of Francesco Bonacina, to work on the CMS ECAL laser monitoring system for channel alignment in time, 2017

   Three month of supervision, from teaching the basis of ROOT and C++ to the data analysis to determine the feasibility of using the ECAL laser monitoring system to align channels in time

5. Supervision of M2 student Stefano Marelli, for the final year thesis (about 10 month of work), 2006

   The work consisted in the feasibility study of the calibration of the CMS ECAL with minimum ionizing particles from collisions. This work was precursory for the ECAL calibration with cosmic rays prior installation in the detector, which has been done in the subsequent years.

Teaching responsibilities

1. Laboratory assistant for the M2 physics laboratory, Paris-Sud University, for the years 2009, 2010, 2011

   Particle physics laboratory (spectroscopy, muon life-time, etc.)

2. Laboratory assistant for the "Physics laboratory", Department of Physics, Milano-Bicocca University, 2006

   Mechanics and optics experiments of the first year physics students

3. Laboratory assistant for the "Computer science laboratory", Department of Physics, Milano-Bicocca University, 2004

   Linux, C, C++, ROOT

4. Laboratory assistant for the "Computer science for physics laboratory", Department of Physcis, Milano-Bicocca University, 2004

   Linux, C, numerical analyses

5. Assistant professor for the lectures "Physics", Department of Geological Sciences and Technologies, Milano-Bicocca University, 2004

   Teaching and exercising for the first year physics course: motion, mechanics, stress tensors, fluids

6. Assistant professor for the lectures "Physics", Department of Geological Sciences and Technologies, Milano-Bicocca University, 2003

   Teaching and exercising for the first year physics course: motion, mechanics, stress tensors, fluids

7. CERN official guide since 2002 and CMS guide since 2018, with related activities during periods at CERN

8. Didactic collaboration for the exposition "Toys, experiments, ideas (GEI)", realized by the "Centro Laboratorio per la Didattica della Fisica del CIRD dell'Università degli Studi di Udine" for the setup in the municipality of Bresso (Milano, Italy), 2000

   Realization of toys and experiments for elementary school students and general public kids, with guided tours (isochronous pendula, shaped bubbles, water rockets, electrostatic experiments with Van-der-Graaf, etc.)

9. Didactic collaboration for the exposition "Toys and science", realized by the Physics Department of the Trento University, for the setup in the municipality of Bresso (Milano, Italy), 1999

   Realization of toys and experiments for elementary school students and general public kids, with guided tours (isochronous pendula, shaped bubbles, water rockets, electrostatic experiments with Van-der-Graaf, etc.)

Other main responsibilities

1. System Manager of the CMS Electromagnetic Calorimeter

   The work consists in managing the electromagnetic calorimeter of CMS (ECAL), a detector composed of $PbWO_4$ crystals (75k channels) with two layers of a silicon/lead "preshower" (138k channels) in front of the two forward parts. The ECAL collaboration consists of approximately 150 physicists from 40 Institutes from 15 countries, with a total budget of about 600 kEUR/year. The responsibility includes the maintenance and operations of the existing detector, the optimization of its performance, from event triggering to particle reconstruction, the preparation of the new electronics for the High Luminosity LHC upgrade. It also includes the approval of results, whose publication is supervised with the help of an editorial board, and their submission to conferences.

2. Convener of the analysis group of the Higgs boson decay into two photons

   This responsibility was taken during the first collision of the LHC at 13 TeV, a crucial moment of the machine. The Higgs boson was "rediscovered" at the new collider energy and the era of precision measurements started. The work consisted in participating to and supervising the analyses of the Higgs boson decaying into two photons: total and differential cross-sections, simplified template cross-sections, low mass analysis, Dalitz decays. About 40 people worked on these analyses.

3. Convener of the CMS ECAL Detector Performance group

   The responsibility consisted in coordinating the work on the detector to reach the ultimate performance for electron and photon reconstruction. Calibration, pile-up and detector effect mitigation, amplitude and time reconstruction. This has been carried out after the laser monitoring and then calibration responsibilities, which were at the time of the Higgs boson discovery, when the calibration and resolution have been fundamental.

4. Evolution of computing tools at IRFU for the LHC experiments

   This is a shared responsibility that has been given to myself, a physicist of the Department of Particle Physics (DPhP) and an computer engineer from the Detector Department (Dedip), by the head of the Irfu of CEA/Saclay, upon proposal from the head of the DPhP and Dedip. It mainly consists in establishing the status of the computing at Irfu; estimating the evolution of the needs, in term of computing and human resources; representing the LHC experiments within the Irfu and outside the institute, also in the context of CEA-IN2P3 collaborations. It is closely related to the computing Grid for LHC and the development of High Parallel Computing (HPC) and new technologies such as usage of Graphics Processor Units (GPUs).

ATTESTATION

N/REF : IRFU/DIR/GRH/22-ED

I, the undersigned, Elise DOUET, Assistant of the Director of IRFU in charge of Human Resources at the Paris-Saclay Research Centre, certify that

Mr Philippe GRAS

benefits, since August 29, 2005, from a permanent position contract at the Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA). He is employed as a researcher in our institute and has supervised Jelena Mijuskovic during her thesis research work.

This certificate is provided for whatever purpose it may serve.

At Saclay, on January 20, 2022

Elise DOUET

CEA SACLAY - 91191 GIF-SUR-YVETTE CEDEX
Institut de Recherche sur les Lois Fondamentales de l'Univers
IRFU

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Direction de la Recherche Fondamentale
Institut de recherche sur les lois fondamentales de l'univers

Philippe Gras - Curiculam vitae

Born on May 22, 1974 in Montélimar, France
Nationality: French
Contact: philippe.gras@cern.ch

Work history

2015-now	Staff researcher at the Institute of research in the fundamental laws of the Universe (Irfu) of the French Alternative Energies and Atomic Energy Commission (CEA).
2013-2015	Postdoctoral researcher at the Institute of research into the fundamental laws of the Universe (Irfu) of the French Alternative Energies and Atomic Energy Commission (CEA).
1998-1999	French civil service at CERN as engineer in the LHCb group.

Education

2003	PhD in Science, University of Karlsuhe, Faculty of Physics. *A Front-End electronics configuration system for CMS subdetectors and Observability of an MSSM Higgs boson in the 4-b final state.*
1998	Graduated from Ecole Nationale Supérieure de Physique de Strasbourg (now Télécom Physique Strasbourg), option physics and modeling. D.E.A. (equivalent to Master II) Subatomic physics, instrumentation, and modeling from Louis Pasteur University of Strasbourg, IReS.
1996	Bachelor of Science degree in Physics from Louis Pasteur University of Strasbourg.
1992-1995	Classes de mathématiques supérieures (Lycée St-Joseph, Avignon). Classes de mathématiques spéciales P' (Lycée Champollion, Grenoble).

Languages French (native), English (fluent)

Responsibilities in international collaborations

2021-now	Chairperson of the CMS ECAL conference committee
2021-now	Member of the CMS ECAL editorial board
2021-now	Member of CMS Institution Board
2021-now	Member of the CUPID collaboration Technical coordination board
2021-now	Co-coordinator of the CUPID experiment computing and data storage
2019-2020	Physics event generator coordinator for the CMS Higgs-in-two-photons analysis group
2015-2016	Co-convener of the CMS Physics analysis group "Vector boson-plus-jets"
2013-2014	Physics event generator coordinator for the CMS "Vector boson-plus-jets" analysis group
2006-now	Responsible for the CMS ECAL selective readout system
2006-now	Responsible for the data acquisition system and control system of the CMS ECAL laser monitoring system

Editorial and conference organization activities

2021-now	Member of the CMS ECAL editorial board
2020	Reviewer for *Physics Letter B*
2016-2021	Member of the Editorial Board of *Advances in High Energy Physics*
2013-now	Member of the *Les Houches Physics at TeV* workshop organization committee
2010-now	Internal reviewer of CMS physics analyses

Participation in PhD thesis juries

2022	Reviewer for Lorenzo Scavarda's PhD, *Design and development of the Calorimeter for the FOOT experiment*, directed by Prof. S. Argirò and Piergiogio Cerello, PhD.
2020	Jury Member for Louis Moreaux's PhD, *Measurement of the transverse momentum of Drell-Yan lepton pairs over a wide mass range in proton-proton collisions at $\sqrt{s}$ = 13 TeV in CMS*, directed by Prof. L. Favart
2015	Jury member for Alexandre Leonard's PhD, *Measurement of Z boson production in association with jets at the LHC and study of a DAQ system for the Triple-GEM detector in view of the CMS upgrade*, directed by Prof. L. Favart

Research activity highlights

Probing the effects of soft radiations on the production of boson at the LHC, measurement of Drell-Yan process over a wide range and comparison with predictions using transverse momentum parton distribution functions (TMD), measurement of n-jettiness; non-pertubative effect and Pythia8 generator tuning to CMS data.

Study of the production of a vector boson in association with light and heavy flavour jets at the LHC, validation of simulation used the standard model backgrounds to new physics searches, constraining parton distribution functions. Measurement of the production of two prompt photons at the LHC.

Search and discovery of the Higgs boson in the diphoton decay channel. Measurement of production differential cross-section and couplings. Prospect for Yukawa coupling measurement from triboson production involving an off-shell Higgs boson. Search at the LHC for Higgs bosons in the context of the minimal supersymmetry model.

Jet substructures and tagging.

Unveiling the nature of the neutrinos with neutrinoless double-beta decay and the CUPID experiment project.

Online monitoring of crystal response of the CMS electromagnetic calorimeter monitoring, from test beam to operation.

Reading a fine-grain calorimeter with a limited bandwidth and optimal energy measurement: design, realization and commissioning of the CMS electromagnetic calorimeter selective readout processor.

Work experience prior PhD studies

1998-1999	Evaluation of the OPC interface in view of its usage for LHC experiment control system, CERN
1998	Measurement of the absolute gain of gaz mixtures and effect of temperature and pressure for the BaBar experiment drift chamber, CNRS/LAPP, Annecy
1997	Design of a new UV calibration system for the RICH detector of the DELPHI experiment, CERN
1996	Commissioning of a curved elastic analyser for the three-axes neutronic spectrometer IN20 and study of porous silicon with neutronic spectrometry, Laue-Langevin Institute, Grenoble

Publications

More than 1000 publications in international peer-reviewed journals, the full list can be consulted at http://cern.ch/go/VbW9

Selection of publications with a major personal contribution

1. "Observation of a New Boson at a Mass of 125 GeV with the CMS Experiment at the LHC", *Phys.Lett.B* 716 (2012) 30-61, S. Chatrchyan et al.
2. "Observation of a new boson with mass near 125 GeV in pp collisions at $\sqrt{s}$=7 and 8 TeV", *JHEP* 81 (2013), doi:10.1007/JHEP06(2013)081
3. "Light quark Yukawas in triboson final states", A. Falkowski, S. Ganguly, P. Gras, J. Miguel, K. Tobioka, N. Vignaroli, T. You, *JHEP 04 (2021) 023*, doi:10.1007/JHEP04(2021)023
4. "Systematics of quark/gluon tagging", P. Gras, S. Höche, D. Kar, A. Larkoski, L. Lönnblad, S. Plätzer, A. Siódmok, P. Skands, G. Soyez, and J. Thaler, *JHEP 07 (2017) 091*, doi:10.1007/JHEP07(2017)091
5. "Measurements of Higgs boson production cross sections and couplings in the diphoton decay channel at $\sqrt{s}$=13 TeV", A. M Sirunyan et al., *JHEP 07 (2021)*, doi:10.1007/JHEP07(2021)027
6. "Measurements of differential production cross sections for a Z boson in association with jets in pp collisions at $\sqrt{s}$=8 TeV", V. Khachatryan et al., *JHEP 04 (2017) 022*, doi:10.1007/JHEP04(2017)022
7. "Measurements of differential cross sections for associated production of a W boson and jets in proton-proton collisions at $\sqrt{s}$=8 TeV", V. Khachatryan et al., doi:10.1103/PhysRevD.95.052002
8. "Measurement of associated Z + charm production in proton-proton collisions at $\sqrt{s}$=8 TeV, A.M. Sirunyan et al., *Eur.Phys.J.C* 78 *(2018) 4, 287*, doi:10.1140/epjc/s10052-018-5752-x
9. "Measurement of differential cross sections for inclusive isolated-photon and photon+jets production in proton-proton collisions at $\sqrt{s}$=13 TeV", A.M. Sirunyan et al., *Eur.Phys.J.C 79 (2019) 1*, doi:10.1140/epjc/s10052-018-6482-9
10. "Measurement of the differential cross sections for the associated production of a W boson and jets in proton-proton collisions at $\sqrt{s}$=13 TeV", A.M. Sirunyan et al., *Phys.Rev.D* 96 (2017) 7, 072005, doi:10.1103/PhysRevD.96.072005

11. "Measurement of differential cross sections for Z boson production in association with jets in proton-proton collisions at $\sqrt{s}$=13 TeV", A.M. Sirunyan et al., *Eur.Phys.J.C 78 (2018) 11*, doi:10.1140/epjc/s10052-018-6373-0

12. "Energy resolution of the barrel of the CMS electromagnetic calorimeter", P. Adzic et al., *JINST* 2 (2007) P04004, doi:10.1088/1748-0221/2/04/P04004

13. "Laser monitoring system for the CMS lead tungstate crystal calorimeter", M. Anfreville et al., *Nucl.Instrum.Meth.A 594 (2008) 292-320*, doi:10.1016/j.nima.2008.01.104

14. "Measurements of differential Z boson production cross sections in proton-proton collisions at $\sqrt{s}$=13 TeV", A.M. Sirunyan et al., *JHEP 12 (2019) 061*, doi:10.1007/JHEP12(2019)061

15. "Measurements of triple-differential cross sections for inclusive isolated-photon+jet events in pp collisions at $\sqrt{s}$=8TeV, A.M. Sirunyan et al., *Eur.Phys.J.C 79 (2019) 11, 969*, doi:10.1140/epjc/s10052-019-7451-7

16. "Measurement of the Production Cross Section for Pairs of Isolated Photons in pp collisions at $\sqrt{s}$=7 TeV", *JHEP* 01 *(2012) 133*, doi:10.1007/JHEP01(2012)133

17. "Extraction and validation of a new set of CMS PYTHIA8 tunes from underlying-event measurements", A. M. Sirunyan, *Eur.Phys.J.C* 80 (2020), doi:10.1140/epjc/s10052-019-7499-4

18. "Phonon-mediated crystal detectors with metallic film coating capable of rejecting α and β events induced by surface radioactivity", I. C. Bandac et al., *Appl.Phys.Lett. 118 (2021) 18*, doi.org:10.1063/5.0050124

19. "Commissioning and performance of the CMS calorimeter system with proton-proton collisions at the LHC", P. Gras for the CMS collaboration, doi.org:10.22323/1.120.0012

20. "The Selective Read-out Processor for the CMS electromagnetic calorimeter",, N. Almeida, J. Varela, P. Busson, J. L. Faure, O. Gachelin, P. Gras, I. Mandzhavidze, M. Mur, *IEEE Trans.Nucl.Sci.* 52 (2005) 772-777, doi:10.1109/TNS.2005.850946

21. "The control system for the CMS tracker front end", F. Drouhin, P. Figueiredo, P. Gras, C. Ljuslin, C. Maazouzi, A. Marchioro, N. Marinelli, C. Paillard, P. Placidi, P. Siegrist, A. Tsirou, P. G. Verdini, *IEEE Trans.Nucl.Sci.* 49 (2002) 846-850, doi:10.1109/TNS.2002.1039576

22. "Results of the OPC evaluation done within JCOP for the control of the LHC experiments", *Conf.Proc.C 991004 (1999)*, R. Barillere, V. Baggiolini, M. Beharell, D. Chmielewski, P. Gras, H. Milcent, K. Kostro, A. Liiou, V. Khomutnikov

23. "The CMS electromagnetic calorimeter barrel upgrade for High-Luminosity LHC", P. Gras for the CMS collaboration, *J.Phys.Conf.Ser.* 587 (2015), doi:10.1088/1742-6596/587/1/012016

24. "The CMS Experiment at the CERN LHC", S. Chatrchyan et al., *JINST 3 (2008) S08004*, doi:10.1088/1748-0221/3/08/S08004

Jelena Mijušković

Address: VI Crnogorske T10, 81400, Nikšić, Montenegro

Email address: jelenamijuskovic@yahoo.com **Phone number:** (+382) 68660343

Date of birth: 14/12/1993 **Nationality:** Montenegrin

WORK EXPERIENCE

[07/2017 – Current] **Trainee researcher**

CERN - European Organization for Nuclear Research

Address: Geneva, Switzerland
Main activities and responsibilities:
Included in projects as a member of CMS group of University of Montenegro and University Paris-Saclay

[03/2018] **International Master Classes 2018 - hands on particle physics**

Main activities and responsibilities:
- teaching basic concepts in particle physics experimental techniques
- teaching students to perform measurements on real data from particle physics experiments themselves (ATLAS data)

http://www.mna.gov.me/vijesti/183126/Odrzan-drugi-medunarodni-Masterclass-Hands-on-Particle-Physics.html

[10/2017] **Assistant at Open Science Days 2017**

Main activities and responsibilities:
- Promoting CMS experiment
- Assisting in the project Art@CMS

http://www.mna.gov.me/vijesti/177089/Izlozbom-ART-CMS-svecano-otvoreni-sedmi-Otvoreni-dani-nauke.html

[01/2017 – 10/2017] **Physics teacher**

Grammar school "Stojan Cerovic"

Address: Niksic, Montenegro

[03/2017] **Assistant at Winter Science School Ivanova Korita,Montenegro**

Montenegrin Science Promotion Foundation PRONA

Main activities and responsibilities:
- supervision of high school students working on different physics projects

[03/2017] **International Master Classes 2017 - hands on particle physics**

Main activities and responsibilities:
- teaching basic concepts in particle physics theory
- teaching students to perform measurements on real data from particle physics experiments themselves (CMS data)

http://www.mna.gov.me/vijesti/170365/Odrzan-prvi-medunarodni-Masterclass-Hands-on-Particle-Physics.html

'06/2016 – 19/08/2016] **Student at CERN Summer Student Programme**

CERN - European Organization for Nuclear Research

Address: Geneve, Switzerland
Main activities and responsibilities:

- work on a project (4 - 8 hours per day), the report on which you can find at: http://cds.cern.ch/record/2209186/files/Report_JM.pdf
- attending lectures on different topics
- visits to experimental facilities, data and control centers

/09/2015 – 25/09/2015] **Assistant at CERN's exhibition at Open Science Days 2015**

Ministry of Science

Address: Montenegro
Main activities and responsibilities:

- demonstrating interactive experiments
- teaching about basic concepts of particle physics

EDUCATION AND TRAINING

[11/2018 – Current] **PhD in Physics**

University of Montenegro and University Paris-Saclay

[10/2017 – 10/2018] **Master Degree in Physics**

Faculty of Natural Sciences and Mathematics, University of Montenegro

Address: Podgorica, Montenegro
Thesis: Emisison of μ + μ - pairs in pp interactions at the energy of 5 TeV at CMS experiment

[09/2015 – 10/2016] **Specialist Degree in Physics**

Faculty of Natural Sciences and Mathematics, University of Montenegro

Address: Podgorica, Montenegro
Thesis: Efficiency of detection 134Cs by gamma detector pairs at the angles of 90° and 180°

[09/2012 – 09/2015] **BSc Physics**

Faculty of Natural Sciences and Mathematics, University of Montenegro

Address: Podgorica, Montenegro

LANGUAGE SKILLS

Mother tongue(s): Montenegrin

Other language(s):

English

LISTENING C1 **READING** C1 **WRITING** C1

SPOKEN PRODUCTION C1 **SPOKEN INTERACTION** C1

Italian

LISTENING A2 **READING** A2 **WRITING** A2

SPOKEN PRODUCTION A2 **SPOKEN INTERACTION** A2

DIGITAL SKILLS

python | C++ | Root CERN | Linux | GIT Hub | Working with CMS Offline Software (CMSSW)

CONFERENCES AND SEMINARS

5/11/2021 – 19/11/2021] **Resummation, Evolution, Factorization Workshop 2021**
https://indico.desy.de/event/28334/

2/07/2021 – 14/07/2021] **Division of Particles and Fields of the American Physics Society (DPF2021)**

The CMS Electromagnetic Calorimeter calibration and performance during LHC Run 2

https://indico.cern.ch/event/1034469/contributions/4431722/

7/06/2021 – 01/07/2021]

22nd International Workshop on Radiation Imaging Detectors (iWoRiD 2021)

High-rate readout with precise time resolution of a high-granularity calorimeter: the case of the CMS Electromagnetic calorimeter upgrade

https://indico.cern.ch/event/820476/contributions/4372898/

3/07/2020 – 17/07/2020] **PyHEP 2020 Workshop**
https://indico.cern.ch/event/882824/

2/07/2020 – 03/07/2020] **CMS Z(+jets) Run II analysis workshop (II)**
https://indico.desy.de/event/26396/timetable/#all.detailed

3/01/2020 – 14/01/2020] **CMS Z (+jets) Run II analysis workshop** Brussels
https://indico.cern.ch/event/855439/

2/05/2019 – 18/05/2019] **New Trends in High-Energy Physics** Odessa, Ukraine

8/01/2019 – 01/02/2019] **CMS Data Analysis School Pisa 2019** INFN Pisa

I/06/2017 – 16/06/2017]

Fifth International Conference on Radiation and Applications in Various Fields of Research (RAD 2017)

Budva, Montenegro

- THE REGISTRATION OF Cs-134 BY GAMMA DETECTOR PAIRS AT AN ANGLE OF 90°

Nikola Svrkota, Jelena Mijušković and Nevenka M. Antović

10.21175/RadJ.2018.01.004

ORGANISATIONAL SKILLS

Organisational skills

- experience in organising the events for science promotion

OMMUNICATION AND TERPERSONAL SKILLS

Communication and interpersonal skills

- good communication skills gained through my work with students teaching physics and science promotions
- experience in intensive collaboration and interaction with many people researching within CMS collaboration
- experienced at giving presentation to large audience

AWARDS

Awards and scholarships

- International Doctoral Action Program (ADI-2018) of the IDEX Université Paris-Saclay
- Scholarship for doctoral research in Montenegro from Ministry of Science Montenegro
- City of Nikšić scholarship for academic achievement

COMMUNAUTE UNIVERSITE GRENOBLE ALPES

ATTESTATION DE REUSSITE AU DIPLOME

Le Président atteste que

l' HABILITATION A DIRIGER DES RECHERCHES Spécialité PHYSIQUE
a été décernée à

Monsieur DELMASTRO MARCO
né le 26 août 1973 à TORINO (ITALIE)

au titre de l'année universitaire 2015/2016

Date de soutenance	: 23 mars 2016
Etablissement soutenance	: COMMUNAUTE UNIVERSITE GRENOBLE ALPES
Jury	: M. GIOVANNI LAMANNA, Président du jury, DIRECTEUR DE RECHERCHE CNRS DELEGATION ALPES M. MATTEO CACCIARI, Rapporteur du jury, PROFESSEUR UNIVERSITE PARIS 7 Mme LYDIA ICONOMIDOU-FAYARD, Rapporteur du jury, DIRECTRICE DE RECHERCHE CNRS DELEGATION ILE-DE-FRANCE SUD M. YVES SIROIS, Rapporteur du jury, DIRECTEUR DE RECHERCHE CNRS DELEGATION ILE-DE-FRANCE SUD Mme ISABELLE WINGERTER-SEEZ, Membre du jury, DIRECTRICE DE RECHERCHE CNRS DELEGATION ALPES
Ecole doctorale	: Physique (Grenoble)

Fait à Grenoble, le 1 avril 2016

COMMUNAUTÉ UNIVERSITÉ GRENOBLE ALPES
Patrick LEVY
Collège Doctoral

N° étudiant : 21560762

Avis important : Il ne peut être délivré qu'un seul exemplaire de cette attestation. Aucun duplicata ne sera fourni.

Marco Delmastro

Curriculum Vitæ

Born on August 26, 1973 – Torino, Italy
Italian nationality
Married, one daughter

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F-74941 Annecy, France

☎ (+33) (0)4 50 09 17 85
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✉ Marco.Delmastro@cern.ch

Areas of specialization and interests

Experimental high-energy physics, from detector prototyping, operations and performance optimization to large-scale data analysis and physics interpretation • Higgs physics • BSM searches with photon and jet final states • QCD precision measurements • Calorimetry • Readout electronics • Signal processing • Science education, communication and dissemination

Appointments held

2020–present Scientific Associate, *CERN*, Switzerland.
2017–present Directeur de Recherche, *CNRS/IN2P3*, *LAPP*, Annecy, France.
2011–2017 Chargé de Recherche 1^{ero} Classe, *CNRS/IN2P3*, *LAPP*, Annecy, France.
2007–2011 Research Physicist Staff, *CERN*, Switzerland.
2005–2007 Fellow, *CERN*, Switzerland.
2003–2005 Post–doctoral Research Associate, *University of Milano*, Italy.
1999–2003 Ph.D. Student, *University of Milano*, Italy.
1998–1999 Post–graduate Research Associate, *Microelectronics and Silicon Detector Group*, *CERN*, Switzerland.

Education

2016 Accreditation to Supervise Research (*Habilitation à Diriger des Recherches, HDR*), *University of Grenoble-Alpes*, France.

THESIS *From ADC counts to the Higgs boson: photons for physics measurements with the ATLAS experiment at the LHC Run 1* (HAL tel-01312862)
REFEREES Prof. M. Cacciari (LPTHE, Paris, France)
Dr. L. Iconomidou-Fayard (LAL, Orsay, France)
Dr. Y. Sirois (LLR, Palaiseau, France)

2003 PHD in Nuclear and Subnuclear Physics, *University of Milano*, Italy (highest honours).

THESIS *Energy reconstruction and calibration algorithms for the ATLAS electromagnetic calorimeter* (CERN-THESIS-2003-033)
SUPERVISOR Prof. L. Mandelli (University of Milano, Italy)
REFEREES Prof. W.E. Cleland (University of Pittsburgh, USA)
Prof. S. Centro (University of Padova, Italy)

1998 MSc ("*Laurea*") in Physics, *University of Torino*, Italy (110/110 *cum laude*, highest honours).

THESIS *Measurement of the J/ψ production at the CERN SPS with the NA50 experiment*
SUPERVISOR Prof. E. Chiavassa (University of Torino, Italy)
CO-SUPERVISOR Dr. N. De Marco (INFN Torino, Italy)

Awards

2014–2017 CNRS *Scientific Excellence Prize* (*Prime d'Excellence Scientifique*), rewarding the 2010-2014 period and awarded for the 2014-2017 period.
2016 Award *Italian Excellence on the Web*, awarded by the Treccani Institute for the Italian Encyclopedia for the article *The particle that wasn't*.
2014 Literary award *Le Due Culture* (*The Two Cultures*) "Maria Antonia Gervasio", awarded to the best

popular-science book published in 2014 to *Particelle familiari* (Editori Laterza, Italy, 2014).

Recent research grants

2016–2021 Principal investigator of the French ANR *PhotonPortal* Project (LAPP-LPNHE-LAL joint project, selected for funding in 2016 for 485'000 €).

Services to the profession

Responsibilities and coordination roles

2020–present Convener of the ATLAS Higgs Working Group.

2018–2020 Convener of the LHC Higgs Cross-Section Working Group 2 *Higgs Properties*.

2017–2020 ATLAS Analysis Contact for the $H \to \gamma\gamma$ *couplings* analysis.

2017–2020 Member of the ATLAS Liquid Argon (LAr) Phase II Upgrade Steering Group.

2017–2020 Convener of the ATLAS LAr Phase II Calibration Upgrade Working Group.

2017–2020 Coordinator of the ATLAS LAr activities at LAPP Annecy.

2016–2017 Convener of the ATLAS Higgs *HGamma* Working Group ($H \to \gamma\gamma$, $H \to Z\gamma$, low and high-mass $\gamma\gamma$ resonances, $HH \to \gamma\gamma b\bar{b}$, $HH \to \gamma\gamma WW$, mono-Higgs Dark Matter and heavy scalar searches with $\gamma\gamma + E_{\mathrm{T}}^{\mathrm{miss}}$)

2015–2016 ATLAS Analysis Contact for the *Search for Higgs-like $\gamma\gamma$ resonances* analysis.

2012–2014 Member of the ATLAS Physics Coordination group.

2012–2014 Convener of the ATLAS e/γ (electron/photon) Combined Performance group.

2011–2012 Member of the ATLAS LAr Calorimeters Management and Steering Groups.

2011–2012 Convener of the ATLAS LAr Calorimeters Software and Data Preparation group.

2011–2012 Coordinator of the ATLAS Photon Identification working group.

2010–2011 Convener of the ATLAS Standard Model Direct Photons working group.

2009–2011 Coordinator of the photon analysis activities of the CERN ATLAS Team.

2005–2010 Convener of the ATLAS LAr Calorimeter Electronic Calibration working group.

Conference and school organization

2019 Organizer of the parallel session *Quel avenir pour la physique des particules?* (What future for particle physics?) at the *25e Congrès Général de la Société Française de Physique*, Nantes, France, July 8–12 2019.

2013–present Member of the organizing committee of Les Houches Workshop *Physics at the TeV Colliders*.

2017 Member of the organizing committee of the ENIGMASS Lectures *Neutrino physics*, LAPP Annecy, France.

2016 Member of the organizing committee of the ENIGMASS Lectures *Searching for Dark Matter at the LHC*, LSPC Grenoble, France.

2015 Member of the organizing committee of the ENIGMASS Lectures *Probing Naturalness and Electroweak Symmetry Breaking at LHC Run 2*, LAPP Annecy, France.

2014 Organizer and Chairman of the Higgs session, *Physique ATLAS France* Workshop 2014.

2012 Organizer of the *Workshop on Photon Physics and Simulation at Hadron Colliders*, Paris, March 2012.

2009 Organizer and chairman of the *Photon Reconstruction and Identification* session, ATLAS e/γ Workshop, Leysin, Switzerland.

2007 Organizer and chairman of the *Electronic Calibration* session, ATLAS Electromagnetic Calorimeter Calibration Workshop, Annecy, France.

2004, 2006 Reviewer of the procedures of prediction of the ionization signals of the ATLAS electromagnetic calorimeter for its electronic calibration, ATLAS Calorimetry Calibration Workshops (2004, Slovakia; 2006, Spain).

Research management and evaluation

2020-present Member of the Plenary European Commitee for Future Accellerator (ECFA).

2016–present Member of the Register of Expert Peer Reviewers for Italian Scientific Evaluation (REPRISE).

2012–present ATLAS Liquid Argon Group Representative for the LAPP Annecy group.

2015–2020 Member of the French CERN Fellowship Selection Committee.

2017-2018 Member of LHCC Panel in charge to review the Technical Design Report of the Phase-2 Upgrade of the CMS Barrel Calorimeters.

2011-2015 Organizer and chairman of ATLAS LAPP Weekly Group Meetings.

Editorial activities

2015 Reviewer for *Journal of Instrumentation*.

2014 Reviewer for *The European Physical Journal C*.

2011 Reviewer for *Computer Physics Communications*.

2013 Editor of the Rapport d'Activité LAPP 2009–2012.

2009–present Chairman and member of Editorial Boards for internal review of ATLAS papers.

2009–2011 Member of the Publication Committee of the ATLAS Collaboration.

2009–2011 Responsible of the graphics and typesetting templates for the ATLAS Collaboration articles and plots.

Management and communication training

2019 *Managing Teams program*, CERN training course, Divonne-les-Bains, France.

2006 *Introduction to communication and outreach*, CERN training course, CERN, Switzerland.

Teaching

2014-present Faculty of the *Summer School in Particle and Astroparticle Physics of Annecy-le-Vieux (GraSPA)*, Annecy-le-Vieux (France). *LHC Experimental Physics* (2-hour lectures: 2014, 2015, 2016, 2017, 2018, 2019; no session in 2020 due to COVID sanitary conditions).

2014-present Faculty of the European School of Instrumentation in Particle and Astroparticle Physics (ESIPAP), Archamps (France). *Experimental Subatomic Physics* (15-hour lectures and tutorial: 2014, 2015, 2016, 2017, 2018, 2019, 2020).

2016 *Physics and Communication: science and the media* INFN Researcher Training Course.
Case study: scientific blogs (1 hour).

2014 Accreditation as Associate Professor, Experimental Physics of Fundamental Interactions (*Abilitazione Scientifica Nazionale, Professore di Seconda Fascia, Settore 02/A1, tornata 2012*), Italy.

2014 CERN Italian Teacher Program 2014. CERN (Switzerland), October 12-17, 2014.
Introduction to Experimental Particle Physics (4-hour lectures and tutorials).

2014 Summer School "Science Communication Society 2014". La Morra (Italy), September 7-12, 2014.
The visible researcher (8-hour lectures and exercises on scientific blogging).

2012 XXIV Seminario Nazionale di Fisica Nucleare e Subnucleare. Otranto (Italy), September 21-27, 2012.
Session on *Scientific communication and relationship with media, general public and industry* (2 hours)

2002–2005 Computational Physics Laboratory (*lecturer*). BSc in Physics, *University of Milano*, Italy.
REFERENT: Prof. L. Perini (University of Milano, Italy).

2001–2011 Physics (*secondary level professor, in leave of absence for research reasons*), *I.T.I.S. "Faccio"*, Vercelli, Italy.

2000 Mathematics (*secondary level professor*), *I.T.I.S. "Bodoni"*, Torino, Italy, and *Liceo Scientifico "Galilei"*, Ciriè, Italy.

2000 Qualification to teach Physics in all Italian secondary schools (*"Abilitazione"*, class 38/A).

Student supervision

Supervision and co-supervision of PhD theses

2018-present Luca Franco. *PhD at LAPP, France. Thesis Supervisor.*
PHD THESIS: *Precision Higgs Physics and search for Physics Beyond the Standard Model with the Higgs Boson decaying into two photons with the ATLAS experiment at LHC.*

2016-2019 Saskia Falke. *PhD au LAPP, France. Co-supervised with Dr. T. Guillemin.*
PHD THESIS: *Measurement of Higgs boson properties in the Higgs to diphoton channel with the ATLAS experiment, EFT interpretation of the Simplified Template Cross Section measurements and energy calibration of electrons and photons in ATLAS.* (defended on 17/9/2019. CERN-THESIS-2019-148).
Currently Research Fellow at CERN, Switzerland.

2014-2017 Kirill Grevtsov. *PhD at LAPP, France. Co-supervised with Dr. I. Wingerter-Seez.*
PHD THESIS: *Exploring the diphoton final state at the LHC at $\sqrt{s} = 13$ TeV: searches for new particles, and the Higgs boson mass measurement with the ATLAS detector.* (defended on 4/7/2017. CERN-THESIS-2017-138).
Currently Fellow at DESY, Hambourg, Germany.

2013-2017 Simone Mazza. *PhD at University of Milano, Italy. Co-supervised with Prof L. Carminati.*
PHD THESIS: *Search for new physics in the diphoton channel at the ATLAS experiment at the LHC.* (defended on 27/2/2017. CERN-THESIS-2017-010).
Currently PostDoc at SCIPP, University of California Santa Cruz, USA.

2012-2015 Zuzana Barnovska. *PhD at LAPP, France. Thesis Supervisor.*
PHD THESIS: *Diphoton measurements with the ATLAS detector at the LHC: search for new resonances and study of diphoton production in association with jets.* (defended on 29/09/2015. CERN-THESIS-2015-167).
Currently Post-doc at USTC Hefei, China, based at CERN, in maternity leave.

2010-2013 Maud Schwoerer. *PhD at LAPP, France. Co-supervised with Dr. I. Wingerter-Seez.*
PHD THESIS: *Études des états finals diphoton dans l'expérience ATLAS au LHC: mesure de sections efficaces différentielles, découverte d'une nouvelle résonance dans la recherche du boson de Higgs et étude de ses propriétés* (defended on 27/09/2013. CERN-THESIS-2013-193).
Currently Data scientist at ProbaYes, Grenoble, France.

Supervision of other PhD projects

2012-2013 Angel Campoverde. *PhD at Stonybrook University, USA. Co-supervised with Prof. R. McCarthy.*
PHD THESIS: *Search For Gravitons Decaying To Vector Bosons In Hadronic Final States in proton-proton Collisions at $\sqrt{s} = 8$ TeV Collected With The ATLAS Detector* (defended on 12/08/2015. PDF).
PROJECT: *Study of the Calibration Constants of the Electromagnetic Calorimeter* (ATL-LARG-INT-2013-006).
Currently Post-doc at University of Siegen, Germany.

2012-2013 Guillaume Lefebvre. *PhD at LPNHE, France. Co-supervised with Prof. M. Ridel.*
PHD THESIS: *Étalonnage des jets et mesure de la section efficace de production de paires de quarks top dans le canal hadronique à $\sqrt{s} = 8$ TeV avec l'expérience ATLAS auprès du LHC.* (defended on 26/09/2014. CERN-THESIS-2014-234).
PROJECT: *Impact of the LAr High Voltage corrections on the electromagnetic energy response resolution* (ATL-LARG-INT-2013-001).
Currently Consultant at InovenAltenor, Paris, France.

2009-2010 Stefania Bordoni. *PhD at LPNHE, France. Co-supervised with Prof. M. Ridel.*
PHD THESIS: *Mesure de la section efficace de production des quarks beaux et charmés à partir de leur désintégration semi-leptonique en électrons avec l'expérience ATLAS dans les collisions protons-protons à $\sqrt{s} = 7$ TeV au LHC* (defended on 16/09/2011. CERN-THESIS-2011-246).
PROJECT: *Effect of electronic calibration constant variations on reconstructed cell energy in the ATLAS electromagnetic calorimeter* (ATL-LARG-INT-2011-001).
Currently Fellow at CERN, Switzerland.

2007-2009 Carolina Gabaldon Ruiz. *PhD at University of Madrid, Spain. Co-supervised with Prof. J. Del Peso.*
PHD THESIS: *Calibration of the ATLAS electromagnetic calorimeter and search of the W' exotic boson* (defended on 24/03/2010. PDF).

PROJECT: *Electronic calibration of the ATLAS electromagnetic calorimeter endcaps. Measurement of the drift time in the ATLAS electromagnetic calorimeter using cosmic pulses* (ATL-LARG-INT-2009-010).
Currently Areo Performance Manager at Inmarsat, Nyon, Switzerland.

Master student internships

2018 Luca Franco. *M2/Erasmus internship at LAPP, France. Co-supervised with Prof. E. Meoni, Università della Calabria, Italy.*
MASTER THESIS ("LAUREA MAGISTRALE"): *Study of the Higgs boson production in Vector Boson Fusion through its decay into two photons with the ATLAS detector at LHC*

2017 Florian Eble. *M1 internship at LAPP, France. Co-supervised with Dr. N. Lorenzo Martinez.*
PROJECT: *Study of LAr calibration from Run2 for phase II upgrade.* (ATL-COM-LARG-2017-028).

Summer Student projects

2018 Dimitrios Sidiropoulos Kontos. *CERN Summer Student.*
PROJECT: *Machine Learning techniques for precision Higgs physics, exploiting the Higgs Boson decays into two photons.*

2010 Maud Schwoerer. *CERN Summer Student.*
PROJECT: *First evidence of* $\Upsilon \to e^+e^-$ *events at* $\sqrt{s} = 7$ *TeV in the ATLAS detector.* (ATL-PHYS-INT-2011-054).

2007 Kilian Mueller. *CERN Summer Student.*
PROJECT: *Studies on longitudinal weight extraction for very low energy electrons.*

2006 Martin Skou Andersen. *CERN Summer Student.*
PROJECT: *Optimization of clustering algorithms for very low energy electrons.*

Brief overview of research activities

Higgs physics at the LHC

2007–present ***Search for the Higgs boson and measurement of its properties***

- Search and discovery of the Standard Model Higgs boson with the $H \to \gamma\gamma$ decay with 7 TeV and 8 TeV pp data.
- Measurement of the Higgs boson couplings with the $H \to \gamma\gamma$ with 7 TeV and 8 TeV pp data.
- Measurement of the Higgs boson mass with the $H \to \gamma\gamma$ decay with 7 TeV and 8 TeV pp data; ATLAS Higgs mass Run 1 combination with $H \to ZZ^* \to 4\ell$; ATLAS and CMS Run 1 mass combination.
- Measurements of the Higgs boson couplings, Simplified Template Cross Sections (STXS), mass and width with the $H \to \gamma\gamma$ decay with 13 TeV pp data.
- Effective Field Theory (EFT) interpretation of Higgs properties, both in the $H \to \gamma\gamma$ channel and in the global coupling combination. Global EFT fit (Higgs+EW+top).

2009–present ***Prompt photons production at the LHC***

- Measurement of inclusive prompt photon cross sections in pp collisions at $\sqrt{s} = 7$ TeV.
- Measurement of differential prompt diphoton cross sections in pp collisions at $\sqrt{s} = 7$ TeV.
- Measurement of prompt diphoton production in association with jets in pp collisions at $\sqrt{s} = 8$ TeV.
- Study of sensitivity potential of $Z + j/\gamma + j$ 8 TeV/13 TeV cross-section double ratio.

ATLAS detector, performance optimization and upgrade

2008–present ***Electron and photon energy calibration***

- Electron and photon response calibration, using *in-situ* techniques and MC-based calibration, at test-beam and with pp data.
- Data-driven correction to the electromagnetic calorimeter response; intercalibration of longitudinal layers of electromagnetic calorimeter with photons.
- Final Run 1 electron and photon calibration for the measurement of the Higgs boson mass.
- Run 2 improved electron and photon calibration exploiting lateral electromagnetic shower information.
- Development of an improved correction for the LAr Medium Gain electronic calibration using special $Z \to e^+e^-$ data, to be used to improve the extrapolation of the electromagnetic calorimeter response between the Z and the H bosons' kinematical regimes.

2008–2012 ***Photon identification***

- Optimization of photon identification criteria for 7 TeV and 8 TeV data taking.
- Data-driven measurement and correction of Data/MC discrepancies of electromagnetic shower shapes.
- Data-driven measurement of photon identification efficiencies.

2008–present ***Liquid Argon calorimetry***

- ATLAS Liquid Argon (LAr) calorimeter detector prototyping, test-beam, assembly and installation.
- LAr electronic calibration development, from ADC count to cell energy.
- LAr reconstruction software, simulation and condition database development and maintenance.
- LAr data quality (software setup and maintenance, shifter training and coordination).
- Development of the new front-end calibration board for the LAr calorimeter Phase II HL-LHC upgrade.

Other activities

2014–2017 ***Search for physics beyond the Standard Model at the LHC***

- Search for low and high-mass spin-0 and spin-2 resonances decaying in photon pairs with 8 TeV and 13 TeV pp data.

2013–2015 ***Study of physics potential of a Future Circular Collider (FCC)***

- Projection of Higgs property measurement sensitivity with $H \to \gamma\gamma$ at FCC pp collider at $\sqrt{s} = 100$ TeV

1997–1998 ***Ultra-relativistic heavy ions at the SppS***

- Measurement of the J/ψ suppression in Pb-Pb collision at 158 GeV/c per nucleon with the $\mu\mu$ decay

1998–2000 ***Rad–hard microelectronics for the LHC detectors***

- Development and test of rad-hard *enclosed* transistors for the front-end electronics of the LHC detectors

Summary of scientific production

Publications

As of November 29, 2021, more than 900 publications on peer-reviewed scientific journals. All publications available on INSPIRE; citations and h-index available on SCOPUS, INSPIRE or Google Scholar.

Selected publications

15 publications selected among those representative of my research commitments and achievements, and counting major personal contributions.

[1] ATLAS Collaboration, "Methodology for EFT interpretation of Higgs boson Simplified Template Cross-section results in ATLAS,". https://cds.cern.ch/record/2694284.

[2] ATLAS Collaboration, "Combined measurements of Higgs boson production and decay using up to 80 fb^{-1} of proton-proton collision data at $\sqrt{s} = 13$ TeV collected with the ATLAS experiment," *Phys. Rev. D* 101 no. 1, (2020) 012002, arXiv:1909.02845 [hep-ex].

[3] ATLAS Collaboration, "Observation of Higgs boson production in association with a top quark pair at the LHC with the ATLAS detector," *Phys. Lett.* B784 (2018) 173–191, arXiv:1806.00425 [hep-ex].

[4] ATLAS Collaboration, "Measurements of Higgs boson properties in the diphoton decay channel with 36 fb^{-1} of pp collision data at $\sqrt{s} = 13$ TeV with the ATLAS detector," *Phys. Rev.* D98 no. 5, (2018) 052005, arXiv:1802.04146 [hep-ex].

[5] ATLAS Collaboration, "Search for resonances in diphoton events at $\sqrt{s}$=13 TeV with the ATLAS detector," *JHEP* 09 (2016) 001, arXiv:1606.03833 [hep-ex].

[6] ATLAS Collaboration, "Measurement of Higgs boson production in the diphoton decay channel in pp collisions at center-of-mass energies of 7 and 8 TeV with the ATLAS detector," *Phys. Rev.* D90 no. 11, (2014) 112015, arXiv:1408.7084 [hep-ex].

[7] ATLAS and CMS Collaborations, "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, arXiv:1503.07589 [hep-ex].

[8] ATLAS Collaboration, "Measurement of the Higgs boson mass from the $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ channels with the ATLAS detector using 25 fb^{-1} of pp collision data," *Phys. Rev.* D90 no. 5, (2014) 052004, arXiv:1406.3827 [hep-ex].

[9] ATLAS Collaboration, "Electron and photon energy calibration with the ATLAS detector using LHC Run 1 data," *Eur. Phys. J.* C74 no. 10, (2014) 3071, arXiv:1407.5063 [hep-ex].

[10] ATLAS Collaboration, "Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC," *Phys. Lett.* B716 (2012) 1–29, arXiv:1207.7214 [hep-ex].

[11] ATLAS Collaboration, "Search for the Standard Model Higgs boson in the diphoton decay channel with 4.9 fb^{-1} of pp collisions at $\sqrt{s} = 7$ TeV with ATLAS," *Phys. Rev. Lett.* 108 (2012) 111803, arXiv:1202.1414 [hep-ex].

[12] ATLAS Collaboration, "Measurement of isolated-photon pair production in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector," *JHEP* 01 (2013) 086, arXiv:1211.1913 [hep-ex].

[13] ATLAS Collaboration, "Measurement of the inclusive isolated prompt photon cross-section in pp collisions at $\sqrt{s} = 7$ TeV using 35 pb^{-1} of ATLAS data," *Phys. Lett.* B706 (2011) 150–167, arXiv:1108.0253 [hep-ex].

[14] ATLAS Collaboration, "Readiness of the ATLAS Liquid Argon Calorimeter for LHC Collisions," *Eur. Phys. J.* C70 (2010) 723–753, arXiv:0912.2642 [physics.ins-det].

[15] D. Banfi, M. Delmastro, and M. Fanti, "Cell response equalisation of the ATLAS electromagnetic calorimeter without the direct knowledge of the ionisation signals," *JINST* 1 (2006) P08001.

Communications at international conferences

[1] M. Delmastro, "Higgs couplings and properties measurements: recent results as well as full run-2 and HL-LHC prospects (invited talk)," in *31st Rencontres de Blois, Particle Physics and Cosmology*. 2–7 June, 2019.

[2] M. Delmastro, "Diphoton searches in ATLAS," in *51st Rencontres de Moriond on Electroweak Interactions and Unified Theories*. 12–19 March 216, 2016. https://cds.cern.ch/record/2150667. ATL-PHYS-PROC-2016-046.

[3] M. Delmastro, "Results of $H \to \gamma\gamma$ and $Z\gamma$ from ATLAS," in *Aspen 2013 "Higgs Quo Vadis" conference*. Aspen, CO, USA, 10–15 March, 2013.

[4] M. Delmastro, "Photon and diphoton production at ATLAS," in *Proceedings of the 15th Lomonosov Conference, Moscow State University, 8–24 August, 2011*, pp. 57–60. Moscow, Russia, 2013. arXiv:1111.2223 [hep-ex]. ATL-PHYS-PROC-2011-236.

[5] M. Delmastro, "Searches for the Higgs boson at the LHC," in *Proceedings of the "XXIeme Rencontres de Blois"*. Blois (France), 21–26 june, 2009. arXiv:0909.0493 [hep-ex]. ATL-PHYS-PROC-2009-077.

[6] M. Delmastro, "Recent results of the ATLAS barrel combined test beam," *AIP Conf.Proc.* 867 (2006) 358–365. *Proceedings of the 12th International Conference on Calorimetry in High Energy Physics, CALOR 2006, Chicago, USA, June 5-9, 2006*.

[7] M. Delmastro, "A stand–alone signal reconstruction and calibration algorithm for the ATLAS electromagnetic calorimeter," in *Proceedings of the IEEE Nuclear Science Symposium 2003*. Portland, Or, USA, 19–25 October, 2003.

[8] M. Delmastro, "The ATLAS Liquid Argon calorimeters read–out system," in *Proceedings of the IEEE Nuclear Science Symposium 2003*. Portland, Or, USA, 19–25 October, 2003.

[9] M. Delmastro, "The ATLAS liquid Argon electromagnetic calorimeter: main features, requested physic performances and test–beam results," in *Proc. 6th World Multiconference on Systemics, Cybernetics and Informatics (SCI2002)*. Orlando, Fl, USA, 14–18 July, 2002.

Recent communications at national conferences and workshops

[1] M. Delmastro, "Higgs Review," in *Workshop Physics ATLAS France 2017*. Vogüé, France, 29-31 Mars, 2017. https://indico.cern.ch/event/572873/.

[2] M. Delmastro, "ATLAS electromagnetic physics," in *2nd LPCC Workshop on LHC detector simulations: status, needs and prospects*. CERN, Switzerland, 18–19 March, 2014. https://indico.cern.ch/conferenceDisplay.py?confId=279530.

[3] M. Delmastro, "Direct photons at ATLAS," in *1st Workshop on Photon Physics and Simulation at Hadron Colliders*. Paris, France, 30 March, 2012. https://indico.in2p3.fr/event/5709/.

[4] M. Delmastro, "Four good reasons to be a visible researcher (invited talk)," in *102nd Congress of the Italian Physics Society (SIF)*. Padova, Italy, 26–30 September, 2016. http://www.sif.it/attivita/congresso/102.

[5] M. Delmastro, "Communicate physics with the guise of daily experience (invited talk)," in *Comunicare Fisica 2012*. Torino, Italy, October 8-12, 2012. http://agenda.infn.it/conferenceDisplay.py?confId=4955.

Recent technical reports

[1] F. Bedeschi, M. Convery, H. Danielsson, M. Delmastro, G. Eigen, F. Forti, D. Glenzinski, A. Kluge, A. Kuzmin, F. Lanni, M. Morandin, F. Simon, and A. Smith, "UCG Report on the TDR for the Phase-II Upgrade of the CMS Barrel Calorimeter,". https://cds.cern.ch/record/2304338. CERN-LHCC-2018-004. UCG-027.

[2] A. Collaboration, "Technical Design Report for the Phase-II Upgrade of the ATLAS LAr Calorimeter," Tech. Rep. CERN-LHCC-2017-018. ATLAS-TDR-027, CERN, Geneva, Sep, 2017. https://cds.cern.ch/record/2285582.

[3] ATLAS LAr Calorimeter Group, "Initial Design Review of the ATLAS Liquid Argon Calorimeter System Phase II Upgrade,". https://cds.cern.ch/record/2248382. ATL-COM-LARG-2017-006.

[4] ATLAS Collaboration, "ATLAS Liquid Argon Calorimeter Phase-I Upgrade Technical Design Report," Tech. Rep. CERN-LHCC-2013-017. ATLAS-TDR-022, Sep, 2013. https://cds.cern.ch/record/1602230.

Outreach

Public events

2015–present *Il bosone di Higgs in un bicchiere d'acqua* (The Higgs Boson in a glass of water): a popular science conference targeting students, presented in numerous Italian high-schools and public events (and virtually held in 2020!).

2020 Da dove viene il 99% della massa della materia ordinaria? (Where does 99 % of ordinary matter come from?). Virtual conference for the Leeds EN-IT Interpreting Practice Sessions.

2020 *Misurare le proprietà del bosone di Higgs* (How to measure the Higgs boson properties): virtual conference for the "La Via delle Scienze" Spring 2020 cycle.

2020 *Mattoncini elementari* (Elementary Brick): virtual workshop at the 2020 INFN Kids Summer Camp.

2017 *Comunicare la fisica al tempo dei social?* (How to communicate physics in the social network era?). Public seminar at Università degli Studi di Milano, Milano (Italy), February 28, 2017.

2016 *Fête de la Science 2016*, LAPP Annecy, France. Presentation and projection of BBC documentary movie *Inside CERN*, and animation of following question-and-answers session.

2016 *Il compendio delle teorie squinternate* (The compendium of tattered theories), Conference at the *Festival della Comunicazione*, Camogli, Italy, September 10, 2016

2015 *Explaining the Higgs Boson with LEGO bricks*, Conference at the *Festival delle Scienze*, Rome, Italy, October 2, 2015.

2015 *The dance of science*, invited presentation and round-table discussion on LHC physics at *Orvieto Scienza 2015*, Orvieto, Italy, February 27-28, 2015. In collaboration with INFN.

2015 *Si può spiegare il bosone di Higgs?* (Can the Higgs boson be explained?), Conference at the *Festival della Comunicazione*, Camogli, Italy, September 12, 2015

2014 *FameLab 2014*. Communication trainer for the participants to the Geneva Regional Edition.

2013 Lecturer and volunteer for the CERN Open Days 2013.

2012 *Looking For the Immeasurably Small*. TED talk at TEDx Lake Como, November 19, 2012.

2005–present *ATLAS Guide*. Guided tours of the ATLAS underground experimental area and control room in English, French and Italian.

Books

2014 *Particelle familiari (Familiar particles)*. A popular science book where the job of a particle physicist looking for the Higgs boson gets unveiled in the dialogues with his five-years old daughter, his wife and other members of the family. Published in Italy by Editori Laterza in July 2014. Second edition in 2015, paperback edition in 2016.

Podcast

2020 Tu che sei un fisico (You who are a physicist). A podcast where a particle physicist answer to any question sent from the audience. 8 episodes produced in 2020.

Blogs

2006–present *Borborigmi di un fisico renitente ("Rumbles of a resistant physicist")*. Popular-science blog in Italian, focused on particle physics vulgarization. About 2 millions unique visits since 2009.

2010 *Blogging ICHEP 2010*. Featured blogger of the collective forum about the 35th edition of the International Conference on High Energy Physics (Paris, July 2010).

TV and radio

2016 Participation to the *Inside CERN* documentary movie by BBC 2 Horizon.

2015 Participation to the TV show *It's all Einstein's fault! ("Tutta colpa di Einstein")*, Italia 1, Italy.

2010–present Numerous interviews and interventions at panels on the Italian and Swiss public radios, addressing the state-of-the-art of particle-physics.

14/02/2019	*What happens during the LHC shutdown?*	Le Oche, Radio Popolare Milano
08/06/2017	*The practical value of science*	Millevoci, RSI
28/02/2017	Interview by *BreakingLab* podcast	Radio Statale
17/09/2016	Interview with *It's all Einstein's fault!* conductor	RSI
30/01/2016	*Einstein's garden: the electroweak force*	RSI
10/02/2015	*The history of the Higgs boson*	StoccolmaRoma podcast
11/11/2014	*The science of Interstellar*	Radio 3 Scienza, Radio 3
05/08/2014	Interview about *Familiar particles* book	Radio 3 Scienza, Radio 3
08/10/2014	*Seeing the invisible*	Memos, Radio Popolare Milano
16/10/2013	*A nearly-Nobel Prize for CERN*	Scintille, RSI
26/06/2013	*Particle physics and LEGO bricks*	Scintille, RSI
05/07/2012	*Emotions and reactions after the Higgs discovery*	Radio 3 Scienza, Radio 3
02/07/2012	*Rumours and scientific communication*	Radio 3 Scienza, Radio 3
25/10/2011	*Superluminal neutrinos?*	Scienza Speciale 42, RSI
05/10/2011	*What's behind superluminal neutrinos?*	Radio 3 Scienza, Radio 3
09/05/2011	*What else is there in the cosmos?*	Millevoci, RSI
05/04/2010	*The particle physics "commune"*	Radio 3 Scienza, Radio 3

Press

2014 *Comics & Science @ CERN*. Organizer and co-author of the comic book "OraMai" (*"NeverNow"*), in collaboration with the CERN Internal Communication office.

2012–present Articles and interviews on various newspaper and magazines.

03/09/2016	*The crackpot index*	Il Manifesto (Alias)
19/12/2015	*Something new at the LHC? Only time will tell*	Le Scienze (Italian edition of *Scientific American*)
10/09/2015	*Little Einsteins*	Style Piccoli (interview)
09/10/2013	*A model Nobel*	La Nazione Ticino
04/02/2014	*Sixty years of CERN*	La Nazione Ticino (interview)
12/2013	*Imagine a night at CERN*	Meridiani Svizzera (interview)
10/2012	*scientists and navigators*	D la Repubblica N. 813 (interview)
09/2013	*Elementary physics of everyday time*	Camminiamo Insieme (interview)

2012–2015 Author of the science section of DafDaf (Italian monthly magazine for children aged 6-11).

05/2015	*Why do metal boats float, and metal spoon sink?*	DafDaf n. 56
02/2015	*My name is Philae, and I ride a comet*	DafDaf n. 53
08/2014	*Measuring time*	DafDaf n. 49
06/2014	*Finding the way among the stars*	DafDaf n. 46
04/2014	*Why it is dark at night?*	DafDaf n. 43
12/2013	*Bits of cosmic honey*	DafDaf n. 39
07/2013	*Colors appearing, colors disappearing*	DafDaf n. 34
02/2013	*Mathematics and soap balls*	DafDaf n. 29
08/2012	*Water*	DafDaf n. 23
07/2012	*Air*	DafDaf n. 22
05/2012	*DIY spectroscopy*	DafDaf n. 20
04/2012	*It lives, it's yeast*	DafDaf n. 19
02/2012	*What do plants eat?*	DafDaf n. 17

Expositions

2016 Video presence in the renewed CERN Microcosm.

2016 Presence (audio interview, personal object locker) in the *Extreme* permanent exposition at the Science Museum in Milano, Italy, a joint project with CERN and INFN.

2014 *The daily life of a particle physicist*: activity during the Open Night 2014 at the Science and Technology Museum of Milano, Italy.

Languages

Italian (native speaker). *English* (fluent). *French* (fluent).

Last updated: November 29, 2021

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Friday 23 August 2019

Private & Confidential
Dr Ulla Blumenschein
Physics and Astronomy
Science and Engineering
Mile End

Dear Dr Blumenschein,

Re: Academic Promotions Round 2019

I am writing to let you know the progress of the application that you submitted earlier this year for the Academic Promotions Round for Senior Lecturer.

I am pleased to inform you that the Academic Promotions Group is recommending that you should be promoted to Senior Lecturer. This decision was made after the Group read your application and CV.

Therefore, with effect from 1 October 2019, your salary will be paid at the rate of . . . per annum, Spinal Point 45, Grade 7 of the Queen Mary Pay and Grading Structure. All other terms and conditions remain unchanged.

I will implement this variation of contract on receipt of confirmation of your acceptance via email to me. Following this, you will receive an updated job profile for your new appointment.

Congratulations on your successful application, which is well deserved.

Yours sincerely,

R Jones

Rhianne Jones
Reward & Benefits Administrator

cc Head of School
Personal File

Dr Ulla Blumenschein

Senior Lecturer in Particle Physics

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Room Number: G. O. Jones Building, Room 407
Office Hours: Tuesdays, 9-10 am, Mondays, 1-2pm

Profile Teaching Research Publications Supervision Public Engagement

Profile

Qualifications:

- Diploma in Biology (corresponds to an MSci), Mainz University
- PhD in Physics, Freiburg University
- Habilitation (higher education qualification), Goettingen University

Research Expertise:

- Plant biology (physiological indicators of forest damage)
- Particle detectors, Calorimetry: Construction of a PbF2 calorimeter and commissioning and operation of a steel-scintillator sampling calorimeter, calibration and monitoring readout, DCS and monitoring software
- Particle detectors, Trigger: Monitoring, simulation, electron/photon trigger development, operation
- Particle physics data analysis: QCD and EWK physics: analysis management and review, associated Z/W+jets production; Higgs physics: Yukawa coupling to fermions; Beyond-Standard-Model physics: Search for Supersymmetry (gauginos, leptons), search for heavy charged and neutral Higgs bosons (2HDM and other models), search for heave gauge bosons (Z')
- Big data, software: Fortran, C++, python, data skimming and slimming management, analysis software management

Starting from the academic year 2017/18, I have been **PhD progression tutor of the Particle Physics department (PPRC)** at the School of Physics and Astronomy. I am also the STFC contact at the School of Physics and Astronomy for matters related to PhD scholarships and the contact for the Graduate training network **GRADnet** of the South East Physics network **SEPnet**. I am also the contact for the **NExT** Institute.

Starting from the academic year 2020/21 I have been deputy exam board chair and acting exam board chair of the **School of Physics and Astronomy**. In this role, I have managed the exam paper review and the execution of the semester A and the semester B main exams and of the summer LSR exams, dealing with plagiarism cases, interacted with external examiners and chaired several UG SEB meetings.

I have also been a member of the task forces for the development and implementation of a **blended teaching approach** at the School of Physics and Astronomy in the academic years 2020/21 and 2021/22. In this functionality, I have worked on the implementation of new assessment strategies and a hybrid classroom approach.

I am deputy leader of the PPRC **ATLAS Level-1 calorimeter** trigger group.

Brief research summary

I have dedicated my physics research to High-energy physics at particle colliders.

During my **UG studies at Mainz university**, I participated in the construction of the A4 calorimeter at the MAMI accelerator at Mainz University, and in the construction of the Compass experiment at the SPS at CERN in Switzerland.

During my **MSc in Mainz**, I developed and performed a search for supersymmetric particles, sleptons, indirect production and through gaugino cascades, at the electron-positron collider at LEP. I managed to derive the first lower limit on the selectron mass which was independent of the mass difference to the lightest supersymmetric particle.

For my **PhD with Freiburg university**, I continued searching for supersymmetry: I established the first search for associated chargino-neutralino production in tri-lepton final states at the D0 experiment at the proton-antiproton collider Tevatron in Illinois. I was also responsible for the calorimeter control system, developed new triggers for isolated electrons and photons and designed the electron/photon trigger suite.

After the PhD, I moved to the ATLAS experiment as a **postdoc with IFAE Barcelona**, where I managed the online and offline commissioning and the first operation of the ATLAS Tile calorimeter. I was also responsible for the analogue calibration and monitoring readout system. I developed the first feasibility study for in-situ jet calibration.

As a **research assistant with Goettingen University**, during LHC Run1, I developed the first measurement of associated Z+jets production and later managed all measurements with W and Z bosons. I also searched for Higgs bosons in decays to 2 tau-leptons. I have developed trigger monitoring software and participated in the operation of the ATLAS detector, as a calorimeter, trigger and monitoring expert and as a shift leader. I was

reorganized the software for Run-2.

In LHC Run2, I managed all ATLAS measurements of QCD and electroweak processes, a position where I reported directly to the Physics Coordination. I also published the first Z+jets cross-section measurement at cms energies of 13TeV and established the Higgs-Yukawa coupling to fermions, using Higgs decays to two tau-leptons. I also worked on tau identification and the reconstruction of di-tau final states. I participated in the operation of the ATLAS detector as ARC shift leader. During LHC Run2, I moved to PPRC at QMUL.

I am currently performing measurements of the production of Z bosons in association with high-energetic jets and in association with charm and bottom quarks, both key backgrounds to Higgs and BSM searches. I am also searching for charged and neutral heavy Higgs bosons arising from 2HDM models and for new heavy gauge bosons, in decays to Z or W boson and light Higgs boson.

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Profile Teaching Research Publications Supervision Public Engagement

Teaching

UG teaching:
2008-2016:

- *Nuclear and Particle Physics* (BSc/MSc, module-assistant)
- *Physics of the Higgs boson* (BSc/MSc, module organizer)
- *Statistical data analysis* (BSc/MSc, module organizer)
- *Physics of the atom-shell* (BSc, module-assistant)
- *Physics laboratory* (BSc, module-assistant)
- *Electronics* laboratory (BSc/MSc, module-assistant)
- *Physics for chemists and engineers* (BSc, module organizer)

2017/18:

- SPA4601 *Professional Skills for Scientists* (1st year, Semester A, modul co-organizer)
- SPA4321 *Introduction to C++* (1st year, Semester B, modul organizer)
- SPA7029U/P *Collider Physics* (4th year, Semester B, deputy module organizer)

2018/19:

- SPA4601 *Professional Skills for Scientists* (1st year, Semester A, module co-organizer)
- SPA5201 *Physics Laboratory* (Semester B, module co-organizer)

organizer)

2019/20:

- SPA4601 *Professional Skills for Scientists* (1st year, Semester A, module organizer)
- SPA6306 *Elementary Particpe Physics* (3rd year, Semester A, module organizer)
- SPA7029U/P *Collider Physics* (4th year, Semester B, deputy module organizer)

2020/21:

- SPA6306 *Elementary Particle Physics* (3rd year, Semester B, module organizer)
- SPA4122 Mathematical techniques II (1st year, Semester B, module-assistant)

2021/22:

- SPA6306 *Elementary Particle Physics* (3rd year, Semester B, module organizer)
- SPA4122 Mathematical techniques II (1st year, Semester B, module-assistant)

Teaching development:

From 2008-2016, I have developed the lecture *Physics of the Higgs boson* and introduced two new experiments in the advanced laboratory course. I have also developed the course work for the new course *Nuclear and Particle Physics*.

At QMUL, I have co-developed the course SPA4601 *Professional Skills for Scientists* and significantly upgraded the course SPA6306 *Elementary Particpe Physics*.

PG teaching:

- Statistics course at the German Helmholtz-Alliahz workshop, 2010
- Coordination of seminar presentations and Lecture *LHC results* at the German Autumn School of particle physics, 2011 and 2015
- The organisation of the NExT School 25-28 June 2018 at QMUL
- Lecture *Standard Model and Electroweak Physics* at the Hadron Collider Summer School 2019 in Goettingen
- Lecture series *Precision Tests of the Standard Model* at the Departamento de Fisica de CIVESTAV, Mexico, 2019 in Mexico City
- Lecture *LHC SM, top and B physics*, London Intercollegiate Particle Physics course, 2020
- Texture *Standard Model and electroweak Physics*, at the Hadron Collider Summer School 2021 in Goettingen.

PhD Students:

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charm quarks at ATLAS

- **Tong Qiu:** Search for a massive Higgs boson with the ATLAS detector at the LHC experiment
- **Arran Freegard:** Higher-order QCD & EW corrections for high-energy V+jets production

PhD examination:

- 5 PhD vivas as an internal examiner at QMUL
- 5 PhD vivas as external examiner

PhD Projects:

- Production of a Z boson in association with b and c quarks
- Production of a Z boson in association with jets
- Search for a massive Higgs boson
- Associated Higgs and Z production in final states with b-quarks and leptons

BSc and MSc Projects:

- Regularized unfolding in hadron collider measurements
- Associated production of Z bosons with c or b quarks
- Using Machine Learning to improve the search for new heavy Higgs bosons
- Review of 2-Higgs-Doublet models and experimental tests at colliders
- ATLAS Level-1 calorimeter trigger upgrade: simulation and monitoring

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Research

Research Interests:

I am interested in the **Fundamental forces in nature.** By recreating conditions of the early universe in powerful synchrotrons like the **Large Hadron Collider (LHC),** we aim to improve our understanding of the various forces with the hope to eventually be able to describe them in a unified theory.

The precision of the theoretical description of interactions in high-energy collisions has increased dramatically over the past years, prompting us to test them at a high precision level, with the option to find signs for new physics in deviations from the current models. In the ATLAS experiment, I have been investigating in particular the **Strong Force** by measuring processes where jets of hadrons are produced in association with the massive carriers of the weak force (JHEP 07 (2013) 032 Eur. Phys. J. C77 (2017) 361). Currently, I am focusing on two challenging classes of these interactions: Processes with a **Z boson and bottom or charm quarks** in the final state and processes where a **collinear Z boson** is radiated by a high-energetic quark in the final state. Both processes can mimic important new physics interactions, and must hence be modelled with high precision.

In our Standard Model, the breaking of Electroweak symmetry by the Higgs field leads to massive force carriers and at least one **Higgs boson**, which was

fermion masses (JHEP 04 (2015) 117plain

Models which go beyond that and predict two Higgs doublets (2HDM) with five massive Higgs bosons, could help understand why we have more matter than anti-matter in our universe. In such a model, a heavy new Higgs boson could be produced at the LHC and decay into the light Higgs and a Z boson. I am searching for such processes in final states with leptons and b-quarks.

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Publications

Selected publications:

ALEPH experiment:

- A. Heister et al., [ALEPH Collaboration], Absolute Lower Limits on the Masses of Selectrons and Sneutrinos in the MSSM, Phys. Lett. B 544 (2002) 73-88

D0 experiment:

- V. M. Abazov et al. [D0 Collaboration], Search for supersymmetry via associated production of charginos and neutralinos in final states with three leptons, Phys. Rev. Lett. 95 (2005) 151805.

ATLAS experiment, LHC Run1

- K. J. Anderson et al., A Mobile Data Acquisition System, JINST 2, P07002 (2007).
- G. Aad et al. [ATLAS Collaboration], Measurement of the Z to tau cross-section with the ATLAS detector, Phys. Rev. D 84, 112006 (2011).
- G. Aad et al. [ATLAS Collaboration], Measurement of the production cross-section for Z/gamma* in association with jets in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, Phys. Rev. D 85 (2012) 032009.

boson in the H to tau+ tau- decay mode in $\sqrt{s}$ = 7 TeV pp collisions with ATLAS , JHEP {09} (2012) 070.

- G. Aad et al. [ATLAS Collaboration], Measurement of the production cross-section of jets in association with a Z boson in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector, JHEP 07(2013) 032.
- G. Aad et al.[ATLAS Collaboration], Evidence for the Higgs-boson Yukawa coupling to tau leptons with the ATLAS detector, JHEP 04 (2015) 117.
- G.Aad et al. [ATLAS Collaboration], Identification and energy calibration of hadronically decaying tau leptons with the ATLAS experiment in pp collisions at $\sqrt{s}$ = 8 TeV, Eur. Phys. J. C (2015).

ATLAS experiment, LHC Run2

- G. Aad et al. [ATLAS Collaboration], Measurement of W and Z-boson production cross-sections in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector, Phys. Lett. B 759 (2016) 601.
- G. Aad et al. [ATLAS Collaboration], Measurements of the production cross-section of a Z boson in association with jets in pp collisions at $\sqrt{s}$ =13 TeV with the ATLAS detector, Eur. Phys. J. C77 (2017) 361.
- M. Aaboud et al. [ATLAS Collaboration], Cross-section measurements of the Higgs boson decaying into a pair of tau-leptons in proton-proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector, Phys. Rev. D 99 (2019) 072001
- M. Aaboud et al. [ATLAS Collaboration], Evidence for the production of three massive vector bosons with the ATLAS detector, Phys. Lett. B 798 (2019) 134913
- M. Aaboud et al. [ATLAS Collaboration], Measurements of the production cross-section for a Z boson in association with b-jets in proton-proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector, JHEP 07 (2020) 044
- ATLAS collaboration, Measurements of the production cross-section of a Z boson in association with high transverse momentum jets in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector, ATLAS-CONF-2021-033
- ATLAS collaboration, Search for heavy resonances decaying into a Z boson and a Higgs boson in final states with leptons and b-jets in 139 fb−1 of pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector, ATLAS-CONF-2020-043

Reviews:

- U. Blumenschein et al., Pushing the precision frontier at the LHC with V+jets, hep-ex/1802.02100 .
- U. Blumenschein, Jet production in association with vector bosons or top quarks ,Int. J. Mod. Phys. A, 30, 1546007 (2015).

Complete list of publications with my involvement:

- Aad G, Abbott B, Abbott DC et al. (2020). **Measurements of the production cross-section for a Z boson in association with b-jets in proton-proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector.**
DOI: 10.1007/JHEP07(2020)044
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/66059

three massive vector bosons with the ATLAS detector.
DOI: 10.1016/j.physletb.2019.134913
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/61158

- Aad G, Abbott B, Abbott DC et al. (2019). Measurement of the inclusive cross-section for the production of jets in association with a Z boson in proton–proton collisions at 8 TeV using the ATLAS detector.
DOI: 10.1140/epjc/s10052-019-7321-3
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/65562

- BLUMENSCHEIN U (2019). Cross-section measurements of the Higgs boson decaying into a pair of tau-leptons in proton-proton collisions at s√=13 TeV with the ATLAS detector.
DOI: 10.1103/PhysRevD.99.072001
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/59459

- Aaboud M, Aad G, Abbott B et al. (2019). Measurement of the four-lepton invariant mass spectrum in 13 TeV proton-proton collisions with the ATLAS detector.
DOI: 10.1007/JHEP04(2019)048
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/59499

- The ATLAS collaboration (2018). Measurement of dijet azimuthal decorrelations in pp collisions at s =8 TeV with the ATLAS detector and determination of the strong coupling.
DOI: 10.1103/PhysRevD.98.092004
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/54884

- Aaboud M, Aad G, Abbott B et al. (2018). Measurement of the Soft-Drop Jet Mass in pp Collisions at sqrt[s]=13 TeV with the ATLAS Detector..
DOI: 10.1103/PhysRevLett.121.092001
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/54885

- Aaboud M, Aad G, Abbott B et al. (2018). Measurement of inclusive jet and dijet cross-sections in proton-proton collisions at √s=13 TeV with the ATLAS detector.
DOI: 10.1007/JHEP05(2018)195
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/43505

- Aaboud M, Aad G, Abbott B et al. (2018). Measurement of differential cross sections and W^+/W^- cross-section ratios for W boson production in association with jets at √s=8 TeV with the ATLAS detector.
DOI: 10.1007/JHEP05(2018)077
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/43506

- Aaboud M, Aad G, Abbott B et al. (2018). Measurement of the cross section for isolated-photon plus jet production in ppcollisions at √s=13TeV using the ATLAS detector.
DOI: 10.1016/j.physletb.2018.03.035
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/43503

- Aaboud M, Aad G, Abbott B et al. (2018). Measurement of the production cross section of three isolated photons in pp collisions at √s=8 TeV using the ATLAS detector.
DOI: 10.1016/j.physletb.2018.03.057
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/43486

- Aaboud M, Aad G, Abbott B et al. (2018). Measurement of τ polarisation in $Z/\gamma^* \to \tau\tau$ decays in proton–proton collisions at √s=8 TeV with the ATLAS detector.
DOI: 10.1140/epjc/s10052-018-5619-1
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/36185

mass in pp collisions at √s=7TeV with the ATLAS detector.
DOI: 10.1140/epjc/s10052-017-5475-4
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- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of the exclusive γγ → $\mu^+\mu^-$ process in proton–proton collisions at s=13TeV with the ATLAS detector.
DOI: 10.1016/j.physletb.2017.12.043
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/36183

- Aaboud M, Aad G, Abbott B et al. (2017). Determination of the strong coupling constant αsfrom transverse energy–energy correlations in multijet events at √s=8TeV using the ATLAS detector.
DOI: 10.1140/epjc/s10052-017-5442-0
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/31344

- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of the Drell-Yan triple-differential cross section in pp collisions at √s=8 TeV.
DOI: 10.1007/JHEP12(2017)059
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/32335

- The ATLASC, Aad G, Abbott B et al. (2017). Measurement of the double-differential high-mass Drell-Yan cross section in pp collisions at √s = 8 TeV with the ATLAS detector.
DOI: 10.1007/JHEP08(2016)009
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- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of differential cross sections of isolated-photon plus heavy-flavour jet production in pp collisions at s=8 TeV using the ATLAS detector.
DOI: 10.1016/j.physletb.2017.11.054
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/33705

- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of the cross-section for electroweak production of dijets in association with a Z boson in pp collisions at s=13 TeV with the ATLAS detector.
DOI: 10.1016/j.physletb.2017.10.040
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/31287

- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of inclusive and differential cross sections in the H → ZZ* → 4ℓ decay channel in pp collisions at √s=13 TeV with the ATLAS detector.
DOI: 10.1007/JHEP10(2017)132
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/28738

- Aaboud M, Aad G, Abbott B et al. (2017). Study of WWγ and WZγ production in pp collisions at √s=8TeV and search for anomalous quartic gauge couplings with the ATLAS experiment.
DOI: 10.1140/epjc/s10052-017-5180-3
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- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of the inclusive jet cross-sections in proton-proton collisions at √s=8 TeV with the ATLAS detector.
DOI: 10.1007/JHEP09(2017)020
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/28303

- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of the W+ W- production cross section in pp collisions at a centre-of-mass energy of root s=13 TeV with the ATLAS experiment.
DOI: 10.1016/j.physletb.2017.08.047
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differential cross sections for isolated photon pair production in pp collisions at √ s = 8 TeV with the ATLAS detector.
DOI: 10.1103/PhysRevD.95.112005
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- The ATLAS collaboration (2017). Measurement of WW/ WZ? l?qq' production with the hadronically decaying boson reconstructed as one or two jets in pp collisions at vs=8TeV with ATLAS, and constraints on anomalous gauge couplings.
DOI: 10.1140/epjc/s10052-017-5084-2
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/25866

- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of the k t splitting scales in Z → ℓℓ events in pp collisions at √s=8 TeV with the ATLAS detector.
DOI: 10.1007/JHEP08(2017)026
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/25867

- The ATLASC, Aaboud M, Aad G et al. (2017). Studies of Zγ production in association with a high-mass dijet system in pp collisions at √s=8 TeV with the ATLAS detector.
DOI: 10.1007/JHEP07(2017)107
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/28536

- Aaboud M, Aad G, Abbott B et al. (2017). Precision measurement and interpretation of inclusive W+, W- and Z/gamma* production cross sections with the ATLAS detector.
DOI: 10.1140/epjc/s10052-017-4911-9
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/25030

- Aaboud M, Aad G, Abbott B et al. (2017). Measurements of the production cross section of a Z boson in association with jets in pp collisions at √s=13 TeV with the ATLAS detector.
DOI: 10.1140/epjc/s10052-017-4900-z
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/25056

- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of the cross section for inclusive isolated-photon production in pp collisions at root s=13 TeV using the ATLAS detector.
DOI: 10.1016/j.physletb.2017.04.072
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/25090

- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of charged-particle distributions sensitive to the underlying event in √s=13 TeV proton-proton collisions with the ATLAS detector at the LHC.
DOI: 10.1007/JHEP03(2017)157
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/24490

- Aaboud M, Aad G, Abbott B et al. (2017). High-ET isolated-photon plus jets production in pp collisions at s=8 TeV with the ATLAS detector.
DOI: 10.1016/j.nuclphysb.2017.03.006
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/24487

- Aaboud M, Aad G, Abbott B et al. (2017). Search for triboson [Formula: see text] production in pp collisions at [Formula: see text] [Formula: see text] with the ATLAS detector..
DOI: 10.1140/epjc/s10052-017-4692-1
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/22464

- Aaboud M, Aad G, Abbott B et al. (2017). Measurement of W boson angular distributions in events with high transverse momentum jets at s=8 TeV using the ATLAS detector.
DOI: 10.1016/j.physletb.2016.12.005
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/[illegible]

production cross section in proton-proton collisions at √s=8 TeV using the $ZZ \to \ell^-\ell^+\ell'^-\ell'^+$ and $ZZ \to \ell^-\ell^+\nu\nu^-$ decay channels with the ATLAS detector.
DOI: 10.1007/JHEP01(2017)099
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/22645

- Aaboud M, Aad G, Abbott B et al. (2016). Measurement of W^+W^- production in association with one jet in proton–proton collisions at s=8TeV with the ATLAS detector.
DOI: 10.1016/j.physletb.2016.10.014
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/18961

- Aaboud M, Aad G, Abbott B et al. (2016). Measurement of the [Formula: see text] dijet cross section in pp collisions at [Formula: see text] TeV with the ATLAS detector..
DOI: 10.1140/epjc/s10052-016-4521-y
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/18883

- Aaboud M, Aad G, Abbott B et al. (2016). Study of hard double-parton scattering in four-jet events in pp collisions at √s=7 TeV with the ATLAS experiment.
DOI: 10.1007/JHEP11(2016)110
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/18988

- Aaboud M, Aad G, Abbott B et al. (2016). Search for minimal supersymmetric standard model Higgs Bosons H / A and for a [Formula: see text] boson in the [Formula: see text] final state produced in pp collisions at [Formula: see text] TeV with the ATLAS detector..
DOI: 10.1140/epjc/s10052-016-4400-6
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- Aaboud M, Aad G, Abbott B et al. (2016). Measurement of the Inelastic Proton-Proton Cross Section at sqrt[s]=13 TeV with the ATLAS Detector at the LHC..
DOI: 10.1103/PhysRevLett.117.182002
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/18275

- Aaboud M, Aad G, Abbott B et al. (2016). Measurement of the $W^\pm Z$ boson pair-production cross section in pp collisions at s=13 TeV with the ATLAS detector.
DOI: 10.1016/j.physletb.2016.08.052
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/54886

- The ATLASC, Aad G, Abbott B et al. (2016). Measurement of total and differential W^+W^- production cross sections in proton-proton collisions at √s=8 TeV with the ATLAS detector and limits on anomalous triple-gauge-boson couplings.
DOI: 10.1007/JHEP09(2016)029
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/16290

- Abreu R, Abulaiti Y, Acharya BS et al. (2016). Measurement of exclusive γγ →w+W- production and search for exclusive Higgs boson production in pp collisions at s =8 TeV using the ATLAS detector.
DOI: 10.1103/PhysRevD.94.032011
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/18957

- The ATLASC, Aad G, Abbott B et al. (2016). Measurement of the angular coefficients in Z-boson events using electron and muon pairs from data taken at √s = 8 TeV with the ATLAS detector.
DOI: 10.1007/JHEP08(2016)159
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/17688

- Aaboud M, Aad G, Abbott B et al. (2016). Measurement of the total cross section from elastic scattering in pp collisions at [illegible]

DOI: 10.1016/j.physletb.2016.08.020
QMRO: https://qmro.qmul.ac.uk/xmlui/handle/123456789/19707

- Aad G, Abbott B, Abdallah J et al. (2016). Measurement of $W^{\pm}$ and Z-boson production cross sections in pp collisions at s=13 TeV with the ATLAS detector.
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ODLUKU
O IZBORU U ZVANJE

DR IVANA PIĆURIĆ bira se u akademsko zvanje **redovni profesor** Univerziteta Crne Gore za predmete: Fizička mehanika, na Studijskom programu Fizika na Prirodno-matematičkom fakultetu i Fizika na nematičnim fakultetima.

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2009-2016 Rukovodilac Studijskog programa Fizika na PMF-u Univerziteta Crne Gore.

2006- Član međunarodne istraživačke kolaboracije H1 iz oblasti fizike visokih energija

Projekti:

2006-2008 **Prazisionsmessungen und Analyse der Electron-Quark-bei Wechselwirkung The highest Energien sowie suche nach des Phanomenen auerhalb Standardmodel financed by the German Research Foundation DFG (Deutschen Forschungsgemeinschaft).**

2006-2008	H1 eksperiment na HERA akceleratoru
2008-2012	Duboko neelastična elektron (pozitron) proton rasejanja
2012-2016	Završna faza analiza H1 kolaboracije

Reference **2000-2019**:

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59. A Search for Excited Neutrinos in e- p Collisions at HERA

Aaron, F.D.et al. (H1 Collaboration), Phys.Lett. B663 (2008) 382.

60. *Measurement of isolated photon production in deep-inelastic scattering at HERA*

Aaron, F.D. et al. (H1 Collaboration), Eur.Phys.J. C54 (2008) 371.

61. *Three- and Four-jet Production at Low x at HERA*

Aaron, F.D. et al. (H1 Collaboration), *Eur.Phys.J.* C54 (2008) 389.

62. *Measurement of deeply virtual Compton scattering and its t-dependence at HERA*

Aaron, F.D. et al. (H1 Collaboration), Phys.Lett. B659 (2008) 796.

63. Aktas, A.,... I. Picurić,... et al. (H1 Collaboration), *Dijet Cross Sections and Parton Densities in Diffractive DIS at HERA*, JHEP 0710 (2007) 042.

64. *Measurement of inclusive jet production in deep-inelastic scattering at high Q^2 and determination of the strong coupling*

Aktas, A.et al. (H1 Collaboration), Phys.Lett. B653 (2007) 134

65. *Charged Particle Production in High Q**2 Deep-Inelastic Scattering at HERA*

Aktas, A.et al. (H1 Collaboration), Phys.Lett. B654 (2007) 148.

66. *Search for baryonic resonances decaying to Xi pi in deep-inelastic scattering at HERA*

Aktas, A.et al. (H1 Collaboration), Eur.Phys.J. C52 (2007) 507.

67. *Tests of QCD factorisation in the diffractive production of dijets in deep-inelastic scattering and photoproduction at HERA*

Aktas, A.et al. (H1 Collaboration), Eur.Phys.J. C51 (2007) 549.

68. *Search for lepton flavour violation in ep collisions at HERA*

Aktas, A.et al. (H1 Collaboration), Eur.Phys.J. C52 (2007) 833.

69. *Production of D*+- Mesons with Dijets in Deep-Inelastic Scattering at HERA*

Aktas, A.et al. (H1 Collaboration), Eur.Phys.J. C51 (2007) 271.

70. *Diffractive open charm production in deep-inelastic scattering and photoproduction at HERA*
Aktas,A.et al. (H1 Collaboration), Eur.Phys.J. C50 (2007) 1.

71. *Higher baryon resonances in carbon-carbon collisions at 4.2-GeV/c per nucleon*

D. Krpić, S. Drndarević, J. Ilić, G. Skoro, I. Picurić, S. Backović, Eur.Phys.J. A20 (2004) 351.

72. *Baryon resonances in carbon-carbon collisions at 4.2-GeV/c per nucleon*

D. Krpić, G. Škoro, I. Picurić, S. Backović, Phys.Rev. C65 (2002) 034909.

73. *Analyses of transverse momentum spectra in central C + C and C + Ta interactions* at 4.2A-GeV/c beam momentum within a collective flow model and a boundary model

S. Backović, I. Picurić, D. Salihagić, D. Krpić, A. P. Cheplakov, Phys.Rev. C62 (2000) 064902.

Curriculum Vitae of Lydia Iconomidou-Fayard

Born in Athens-Greece on February 13th, 1958
Married, two children
Thesis defended in March1986, University of Paris XI,Orsay
Habilitation defended in March 1994, University Paris XI, Orsay
Director of research at CNRS (National Centre of Research).
Working at IJCLab, Université Paris-Saclay, Orsay, France

Domains of Research

1) Study of W and Z boson properties with the UA2 detector (thesis). Mainly analysis aspects
2) Direct CP Violation in the Kaon system (1986-2002 NA31 and NA48 collaborations at CERN). Construction and commisionning of detectors, performances of various systems, analysis aspects.
3) ATLAS collaboration (2002-..) Electrical measurements on the LArg Calorimeter (2002-2006). Commissioning of the Calorimeter (2006-2008). Electronic calibrations and tools for monitoring (2006-2010). Electron performances, optimization of the reconstruction and measurement of the electron identification efficiencies (2008-2012). Search for the Higgs boson to its decay channel H->ZZ*->4leptons (2009-2014). Upgrade Physics at HL-LHC (2014-2016). Energy layer intercalibration of the LArg Calorimeter (2015-2020). Vector Boson Scattering (2019-). Contribution at the ITK Pixel Detector construction with the Paris-Cluster (2018-).

Activities and positions

--Convener of working or analysis groups (in NA48 and in ATLAS)
--Head of the Lecture Program of the CERN Summer School for students (2002-2004)
--ATLAS-IJCLab (ex-LAL) group leader (2016-2020)
--Member of the Advisory Committee of the ATLAS Collaboration Board (2011-2012)
--Editor and Referee of several internal notes and publications in NA48 and ATLAS.
--ATLAS representative in the study group and editor of "Study of the carreers of people working at CERN", CERN Yellow Report 2019-004.
--Organization / programme committees of various Conferences: "Kaon physics" 1994 Orsay France, "Matter-antimatter asymmetry", 2002 Blois, France, Head of the Experimental program of " Moriond EW" sessions since 2006, "Physics at LHC and beyond", 2014, Quy-Nhon Vietnam, "Precision theory for precise measurements at LHC and beyond" 2016 Quy-Nhon Vietnam, LHCP (online), Paris 2020.
--Member of the French National Committee of Research of IN2P3 from 2002-2008.
--Member of the Scientific Council of IN2P3 from 2002-2006.
--Supervision of 16 interns and of 8 theses, member and referee of 22 theses jurys.
--Member of the Academic Council (2016-), of the Council of Graduate School of Physics (2019-) and of the P2I Department (2018-) of Paris-XI and Paris-Saclay Universities.
--Co-Edititor of the Scientific journal "Elementaire" (http://elementaire.lal.in2p3.fr)
--Referee for European grants (Fellini and ERC).
--Member of the Scientific Council of IJCLab (2020-).

IJCLab
Irène Joliot-Curie
Laboratoire de Physique
des 2 Infinis

Pr. Achille STOCCHI
Directeur du Laboratoire de Physique
des 2 Infinis Irène Joliot-Curie (IJCLAB)
☎+33(0)1 69 15 51 57
@ achille.stocchi@ijclab.in2p3.fr

TO WHOM IT MAY CONCERN

Orsay, April, 27th 2022

CERTIFICATE

Dear Sir/Madam,

I, the undersigned, Achille Stocchi, Director of the IJCLab laboratory, certify that Mrs. Lydia ICONOMIDOU-FAYARD works at the Laboratoire de physique des 2 infinis-Irène Joliot-Curie (IJCLAB) and holds the position of research director of exceptional class.

This certificate is issued to serve the purpose it might be required.

Achille Stocchi

Pr. Achille STOCCHI
Director of IJCLab
CNRS/U-Paris-Saclay/U-Paris-Cité

AREA DEL PERSONALE
SETTORE PERSONALE DOCENTE E RICERCATORE
UFFICIO VALUTAZIONI COMPARATIVE

Al Prof.
Simone ALIOLI
Dipartimento di Fisica "G. Occhialini"
SEDE
e, per conoscenza:

Al Direttore del Dipartimento di Fisica
"G. Occhialini"
Al Responsabile del Centro Servizi di Scienze 1
All'Ufficio Offerta Formativa
All'Area della Formazione e dei Servizi
agli Studenti
Al Servizio Prevenzione e Protezione
All'Ufficio Pagamenti
All'Ufficio Affari Istituzionali
All'Ufficio Fiscale e Previdenziale

LORO SEDI

AL MINISTERO DELL'ISTRUZIONE,
DELL'UNIVERSITA' E DELLA RICERCA
Dipartimento per la Formazione Superiore
e per la Ricerca
P.le Kennedy, 20
00144 ROMA RM

AL CINECA
Via Magnanelli, 6/3
40133 CASALECCHIO DI RENO BO

OGGETTO: Prof. Simone ALIOLI
Nato a Varese il 22.11.1981
Chiamata ai sensi dell'art. 1, comma 9, della Legge 230/2005

Si comunica che, con D.R. n. 16567 del 28.2.2018, la S.V. è stata chiamata a ricoprire il posto di professore di seconda fascia per il settore concorsuale 02/A2 – Fisica Teorica delle Interazioni Fondamentali (ssd FIS/02) presso il Dipartimento di Fisica "G. Occhialini", a decorrere dal 1° marzo 2018.

Distinti saluti.

IL CAPO AREA DEL PERSONALE
(Dott.ssa Elena La Torre)

Responsabile del procedimento: Nadia Terenghi
Pratica trattata da: Conchita Conigliaro – mail: valutazionicomparative@unimib.it – tel.: 02-6448.6193-6114-6436

D.R. n. 16567
Matr. n. 16762

Il Rettore

VISTA la Legge 4.11.2005, n. 230 ed in particolare l'art. 1, comma 9;
VISTA la Legge 30.12.2010, n. 240 ed in particolare l'art. 29, comma 7;
VISTO il D.P.R. 15.12.2011, n. 232 relativo al regolamento per la disciplina del trattamento economico dei professori e dei ricercatori universitari, a norma dell'art. 8, commi 1 e 3, della Legge 240/2010;
VISTO il D.M. n. 855 del 30.10.2015 "Rideterminazione dei macrosettori e dei settori concorsuali";
VISTO il D.M. n. 610 del 9.8.2017 ed in particolare l'art. 5;
VISTA la delibera del 5.5.2017, con la quale il Dipartimento di Fisica "G. Occhialini" ha proposto la chiamata diretta come professore di seconda fascia del Dott. Simone ALIOLI per il settore concorsuale 02/A2 – Fisica Teorica delle Interazioni Fondamentali (ssd FIS/02);
VISTO il parere favorevole espresso dal Consiglio di Amministrazione nella seduta del 20.6.2017;
VISTA la nota prot. n. 14211 del 27.11.2017 con la quale il MIUR ha autorizzato la chiamata diretta del Dott. ALIOLI a valere sulle risorse di Ateneo;
VISTA la delibera con la quale il Consiglio di Dipartimento di Fisica "G. Occhialini", nella seduta del 26.1.2018, ha chiamato sul posto di professore di seconda fascia per il settore concorsuale 02/A2 – Fisica Teorica delle Interazioni Fondamentali (ssd FIS/02) il suddetto docente;
VISTO il parere favorevole espresso dal Consiglio di Amministrazione nella seduta del 27.2.2018;
VISTA la dichiarazione di opzione per il regime di impegno a tempo pieno;
ATTESO che il Dirigente attesta la regolarità e la legittimità del presente provvedimento;

DECRETA

Per le motivazioni indicate nelle premesse del presente provvedimento e che qui si intendono integralmente riportate:

Art. 1 - Il Prof. Simone ALIOLI è chiamato a ricoprire il posto di professore di seconda fascia per il settore concorsuale 02/A2 – Fisica Teorica delle Interazioni Fondamentali (ssd FIS/02) presso il Dipartimento di Fisica "G. Occhialini", a decorrere dall'1.3.2018.
Con effetto dall'assunzione in servizio il Prof. ALIOLI è assegnato alla classe 0 di stipendio con impegno a tempo pieno con la retribuzione di € 33.089,44.= a.l., l'assegno aggiuntivo di € 6.447,03.= a.l., l'indennità integrativa speciale di € 11.294,95.=a.l. ed ogni altro assegno stabilito dalle norme di legge.

Art. 2 - La spesa derivante dall'applicazione del presente decreto graverà nell'apposito conto di bilancio CA. C. 01.01.01.02 (Stipendi e competenze fisse ai professori associati).

Milano, 28 febbraio 2018

IL RETTORE
(Maria Cristina Messa)

UOR Area del Personale – Dirigente: Elena La Torre
Responsabile del procedimento: Nadia Terenghi
Pratica trattata da: Conchita Conigliaro

Curriculum Vitae

Personal Information:

Name: Simone ALIOLI

Date of Birth: 22 November 1981

Place of Birth: Varese (Italy)

Nationality: Italian

Research identifier: orcid.org/0000-0001-8234-2247

Website: cern.ch/alioli

- **Current position:**

  Mar. 2018 - present Associate Professor at the Department of Physics "G. Occhialini", University of Milano-Bicocca, Italy

- **Previous positions:**

  Nov. 2017 - Feb. 2018 Research Fellow at the Department of Physics "G. Occhialini", University of Milano-Bicocca, Italy.

  Nov. 2014 - Oct. 2017 COFUND Theory Fellow at CERN, Geneva, Switzerland.

  Nov. 2011 - Oct. 2014 PostDoctoral Research assistant at the Ernest Orlando Lawrence National Laboratory and at the University of California at Berkeley, Berkeley, CA, U.S.A.

  Nov. 2009 - Oct. 2011 PostDoctoral Research assistant at DESY, Zeuthen, Germany.

  Nov. 2006 - Nov. 2009 PhD student at the Department of Physics "G. Occhialini", University of Milano-Bicocca, Italy.

- **Grants and Awards:**

  Jun 2020: 5-year MIUR grant FARE for project "P4: Precise Predictions for Particle Phenomenology" (240.000 EUR)

  Feb 2018: 5-year Fondazione CARIPLO/Regione Lombardia grant for project "Improved simulations for the LHC and future colliders" (500.000 EUR)

  Nov 2017: 5-year ERC Starting Grant 2016 for project "REINVENT" (1.500.000 EUR)

  Nov 2014: 3-year CERN COFUND Fellowship

  Dec 2010: DESY monetary prize for the development of the "POWHEG-BOX"

- **Education:**

  2009 PhD in Physics and Astronomy, subject Theoretical Physics
  Universitá degli Studi di Milano-Bicocca, Milan, Italy.
  Advisor: Paolo Nason Date of defense: 24/11/2009
  Thesis Title: *Matching Next-to-Leading-Order QCD Calculations with Shower Monte Carlo Simulations: Single Vector Boson and Higgs Boson Productions in POWHEG*

  2006 Master Degree in Theoretical Physiscs, Universitá degli Studi di Milano-Bicocca, Milan, Italy.

  2003 Bachelor Degree in Theoretical Physiscs, Universitá degli Studi di Milano-Bicocca, Milan, Italy.

- **Teaching experience:**

  2018-2021 "Quantum mechanics" course at Milan-Bicocca University (120 hours/year)

  2018 PhD course on "Precision Physics at the LHC" at Milan-Bicocca University (20 hours)

  2016 Supervisor of CERN summer student L. Gellersen (Project: Tuning Geneva+Pythia8 to LHC data with Professor2)

  2015 Tutor at the European School of High-Energy Physics, Bansko, Bulgaria (15 hours)

  2015 Tutor at the CERN-FNAL HCP Summer School, CERN, Geneva, Switzerland (6 hours)

  2010 "LHC Theory" lectures for DESY summer students (4 hours)

  2008-2009 "Quantum mechanics" course assistant at Milan-Bicocca University (30 hours/year)

  2008-2009 "Experimental Physics I" course assistant at Milan-Bicocca University (60 hours/year)

- **Organisation of scientific meetings:**
  - Convener at the CTEQ Workshop on "QCD Tools for LHC Physics: From 8 to 14 TeV: What's needed and why", Fermilab, USA, November 14-15, 2013
  - Convener of the QCD session at the LHCP 2016, Lund, Sweden, June 13-18, 2016
  - Convener of the "Monte Carlo event generator and resummation" session at QCD@LHC 2017, Debrecen, Aug 27 - Sep 1, 2017
  - Convener of the "Top and Heavy Flavour" session at SM@LHC 2018, Berlin, Germany, Apr 10-13, 2018
  - Convener of the QCD session at LHCP 2018, Bologna, Italy, Jun 4-9 2018
- **Institutional responsibilities and community work:**

  2018-2020 Organizer of Joint INFN, Milan-Bicocca and Milan University Pheno Seminars, Milan.

  2016-2017 Organizer of Collider Cross Talks at CERN.

  2013-2014 Organizer of Particle Theory Seminar at LBNL-UC Berkeley.

  2010 Organizer of Theory Seminar at DESY-Zeuthen.

  Since 2015 Referee for EPJ-C.

  Since 2016 Referee for JHEP.
- **Selected Seminars and Colloquia:**
  - Seminar at SISSA, Trieste, Italy, 7 Mar, 2018
  - Plenary talk at "Pushing the Frontiers of Particle Physics During the LHC Run II Era" conference, HKUST, Honk Kong, 25 Jun 2017
  - Talk at ATLAS-CMS Monte Carlo Generators Workshop, CERN, Geneva, Switzerland, 2 May, 2017
  - Seminar at Vienna University, Vienna, Austria, 25 Apr, 2017
  - Talk at Parton Shower, Event Generators and Resummation workshop, Cambridge, UK, 28 Mar, 2017
  - NIKHEF Theory Seminar , Amsterdam, The Netherlands, 16 February, 2017
  - Talk at Resummation, Evolution and Factorization Workshop , Antwerpen, Belgium, 9 November, 2016
  - Talk at Future challenges for precision QCD Workshop, IPPP, Durham, UK, 26 October 2016
  - Theory Seminar at Aspen Center for Physics, Aspen, 22 Aug 2016
  - Theory Seminar at ESI workshop, Vienna, 10 Jul 2016
  - Theory Seminar at TUM, Munich, 19 May 2016
  - HEP Cavendish Seminar at Cambridge University, Cambridge, 10 Nov. 2015
  - Particle and Astro-Particle Physics Seminar at UZH, Zürich, 30 Sep. 2015
  - Particle and Astro-Particle Physics Seminars at CERN, Geneva, 22 May 2015
  - Theory Seminar at Max Planck Institut fur Physik, Münich, 11 May 2015
- **Selected publications:**
  1. *"NLO Higgs boson production via gluon fusion matched with shower in POWHEG"*, S. Alioli, P. Nason, C. Oleari and E. Re., JHEP **0904**, 002 (2009)
  2. *"NLO single-top production matched with shower in POWHEG: s- and t-channel contributions"*, S. Alioli, P. Nason, C. Oleari and E. Re., JHEP **0909**, 111 (2009), JHEP **1002**, 011 (2010)]
  3. *"Jet pair production in POWHEG"* S. Alioli, K. Hamilton, P. Nason, C. Oleari and E. Re, JHEP **1104** 081 (2011)
  4. *"A general framework for implementing NLO calculations in shower Monte Carlo programs: the POWHEG BOX"*, S. Alioli, P. Nason, C. Oleari and E. Re., JHEP **1006**, 043 (2010)
  5. *"Hadronic top-quark pair-production with one jet and parton showering"* S. Alioli, S. O. Moch and P. Uwer, JHEP **1201**, 137 (2012)
  6. *"A new observable to measure the top-quark mass at hadron colliders"*, S. Alioli, P. Fernandez, J. Fuster, A. Irles, S. O. Moch, P. Uwer and M. Vos, Eur. Phys. J. C **73**, 2438 (2013)

7. *"Matching Fully Differential NNLO Calculations and Parton Showers"*, S. Alioli, C. W. Bauer, C. Berggren, F. J. Tackmann, J. R. Walsh and S. Zuberi, JHEP **1406** 089 (2014)
8. *"Drell-Yan production at NNLL'+NNLO matched to parton showers"*, S. Alioli, C. W. Bauer, C. Berggren, F. J. Tackmann and J. R. Walsh., Phys. Rev. D **92**, no. 9, 094020 (2015)
9. *"Precision Probes of QCD at High Energies"* S. Alioli, M. Farina, D. Pappadopulo and J. T. Ruderman, JHEP **1707** 097 (2017)
10. *"Catching a New Force by the Tail"*, S. Alioli, M. Farina, D. Pappadopulo and J. T. Ruderman, Phys. Rev. Lett. **120** (2018)
11. *"NLO QCD corrections to SM-EFT dilepton and electroweak Higgs boson production, matched to parton shower in POWHEG"*, S. Alioli, W. Dekens, M. Girard and E. Mereghetti, JHEP **08**, 205 (2018)
12. *"Higgsstrahlung at NNLL'+NNLO matched to parton showers in GENEVA"*, S. Alioli, A. Broggio, S. Kallweit, M. A. Lim and L. Rottoli, Phys. Rev. D **100**, no.9, 096016 (2019)
13. *"Novel angular dependence in Drell-Yan lepton production via dimension-8 operators"*, S. Alioli, R. Boughezal, E. Mereghetti and F. Petriello, Phys. Lett. B **809**, 135703 (2020)

- **Research visits:**
  - Aspen Center For Physics, Aspen, Colorado, U.S.A. during the program "The LHC Awakens: A New Energy Frontier", 14 Aug.- 4 Sep., 2016
  - ESI, Vienna, Austria, during the program "Challenges and Concepts for Field Theory and Applications in the Era of LHC Run-2", 18-29 July, 2016
  - MITP, Mainz, Germany, during the program "Higher Order and Jets for LHC", 5-18 July, 2015
  - Aspen Center For Physics, Aspen, Colorado, U.S.A. during the program "Frontiers in Particle Physics: From Dark Matter to the LHC and Beyond", 18-24 January, 2014
  - MITP, Mainz, Germany, 1-20 September 2013
  - "TH/LPCC Institute on SM at the LHC", CERN, Switzerland, 1 - 12 Oct. 2012
  - "TEV2011: Physics at TeV Colliders", Les Houches, France 30 May - 8 June 2011
  - Galileo Galilei Institute, Firenze, Italy, during the program "Advancing Collider Physics: from Twistors to Monte Carlo", 24-28 September 2007
- **Selected invitations to international conferences:**
  1. *"Merging NNLO calculations with higher-order resummation and parton showers in GENEVA "*, LoopFest XVIII, Fermilab, USA, 12 Aug. 2019
  2. *"Underlying Event sensitive observables with Monte Carlo"*, ESI 2016, Erwin-Schroedinger Institute, Vienna, 19 Jul. 2016
  3. *"Drell-Yan production at NNLL'+NNLO matched to parton showers in GENEVA"*, SCET 2016, DESY, Hamburg, 23 Mar. 2016
  4. *"Status and Perspectives of NNLO plus Parton Shower Matching"*, DIS 2016, DESY, Hamburg, 13 Apr. 2016
  5. *"Matching NNLO calculations with parton showers in GENEVA"*, PSR workshop, Krakow, Poland, 27 May 2015
  6. *"GENEVA Monte Carlo: status and new developments"*, LoopFest XIII, New York Citi College, 20 Jun. 2014
  7. *"Matching NNLO Calculations and Parton Showers"*, Frontiers in Particle Physics: From Dark Matter to the LHC and Beyond, Aspen, 20 Jan. 2014
  8. *"Top quark physics"*, plenary QCD@LHC 2013, Hamburg, 3 Sep. 2013
  9. *"Matching NLO Calculations and Parton Showers"*, Santa Cruz, 16 Aug. 2013
  10. *"A new observable to determine the top-quark mass at hadron colliders"*, Snowmass Workshop, Seattle, 30 Jun. 2013
  11. *"Combining Higher-Order Resummation with Multiple NLO Calculations and Parton Showers in the GENEVA Monte Carlo Framework"*, Rencontres de Moriond, La Thuile, 14 Mar. 2013
  12. *"Matching NLO QCD to Monte Carlo showers and POWHEG "*, Loops & Legs 2012, Wernigerode, 19 Apr. 2012
  13. *"POWHEG: status and perspectives"* Europhysics Conference on High-Energy Physics 2011, Grenoble, 21 Jul. 2011

February 7, 2021
Simone Alioli

Bibliografija:

- Jelena Mijuskovic on behalf of CMS collaboartion „The CMS electromagnetic calorimeter upgrade: high-rate readout with precise time and energy resolution", Journal of Instrumentation (JINST) 2022 17 C01004

  DOI: https://doi.org/10.1088/1748-0221/17/01/C01004

- Koautor na 29 publikovanih radova CMS kolaboracije. Publikacije dostupne na sajtu publikacija iz oblasti fizike čestica:

  https://inspirehep.net/authors/1712994

- Prezentacije rezultat doktorske disertacije na međunarodnim konferencijama i workšopovima:

1. J. Mijuškovic, High-rate readout with precise time resolution of a high-granularity calorimeter: the case of the CMS Electromagnetic calorimeter upgrade, 22nd International Workshop on Radiation Imaging Detectors, Ghent, Belgium, 27 June 2021 to 1 July 2021. https://indico.cern.ch/event/820476/
2. J. Mijuskovic, The CMS Electromagnetic Calorimeter calibration and performance during LHC Run 2, Meeting of the Division of Particles and Fields of the American Physical Society (DPF21), Florida State University, USA, online, 12–14 Jul 2021. https://indico.cern.ch/event/1034469/
3. J. Mijuskovic, Z + jets: N-jettiness, Journées CMS-France, Physique et Upgrades de Phase-2, 7–9 Oct 2020, online. https://indico.cern.ch/event/881933/
4. J. Mijuskovic, Measuring N-jetiness of DY+jets events, Workshop on DY + 0...N jets measurements with Run II data, 16 December 2021, online. https://indico.cern.ch/event/1101623/
5. J. Mijuskovic, Status of N-jettiness analisys at CMS, Z(+jets) Run II analysis worhshop II, DESY, 2-3 July 2020. https://indico.desy.de/event/26396/timetable/#all.detailed
6. P. Gras, J. Mijuskovic et al., Prospects on N-jettiness measurement at CMS, CMS Z(+jets) Run II analysis worhshop, 13–14 Jan 2020 , IIHE Brussels, Belgium. https://indico.cern.ch/event/855439/

- Najvažnija izlaganja rezultata iz doktorske disertacije na zasijedanjima CMS kolaboracije u CERN-u:

1. Update on N-jettiness measurement, SMP-VJ: Vector Boson Plus Jets meeting, 17 Dec 2021, https://indico.cern.ch/event/1093689/
2. Double-Muon trigger SF, Muon HLT+RECO meeting, 14 Dec 2021 https://indico.cern.ch/event/1106050/
3. Update on N-jettiness measurement, SMP-VJ: Vector Boson Plus Jets meeting, 1 Oct 2021, https://indico.cern.ch/event/1071770/
4. Update on N-jettiness in Z+jets, SMP-VJ: Vector Boson Plus Jets meeting, 23 Jul 2021, https://indico.cern.ch/event/987960/
5. Update on N-jettiness in Z+jets, SMP-VJ: Vector Boson Plus Jets meeting, 23 Jul 2021, https://indico.cern.ch/event/987960/
6. Tracking efficiency in Njettiness studies using UL2018 datase, Tracking Physics Object Group, 14 Jun 2021, https://indico.cern.ch/event/1040448/
7. Run2 resolution studies for Ecal paper, ECAL Detector Performance Group, 26 May 2021, https://indico.cern.ch/event/991265/
8. Update on N-jettiness studies, SMP-VJ: Vector Boson Plus Jets, meeting, 16 Apr 2021, https://indico.cern.ch/event/987953/
9. Dimuon SF for UL2018, 22 Feb 2021,Muon Physics Object Group, https://indico.cern.ch/event/1005603/
10. Njettiness status report, SMP-VJ: Vector Boson Plus Jets meeting, 5 Feb 2021, https://indico.cern.ch/event/987948/
11. Status of the N-jettiness analysis, SMP-VJ: Vector Boson Plus Jets meeting, 18 Dec 2020, https://indico.cern.ch/event/975614/
12. SF for dimuon trigger with UL2018, Muon Physics Object Group, 14 Dec 2020, https://indico.cern.ch/event/984867/
13. ECAL Resolution studies, CMS Week: ECAL General, 2 Dec 2020, https://indico.cern.ch/event/977830/
14. Ecal developments for prompt calibration and time-dependent MC, CMS Week: Plenary on Run-3 preparation, 16 Sep 2020, https://indico.cern.ch/event/952782/timetable/
15. N-jettiness in Z+jets, SMP-VJ: Vector Boson Plus Jets meeting, 17 Jul 2020, https://indico.cern.ch/event/920780/
16. Update on N-jettiness, SMP-VJ: Vector Boson Plus Jets meeting, 22 May 2020, https://indico.cern.ch/event/897915/
17. N-jettiness in Z+jets, SMP-VJ: Vector Boson Plus Jets meeting, 27 Mar 2020, https://indico.cern.ch/event/882833/
18. UL legacy summary plots, ECAL Detector Performance Group, 12 Feb 2020, https://indico.cern.ch/event/871238/
19. UL2017 Ecal resolution tes, Joint ECAL/Egamma meeting, 17 Jan 2020, https://indico.cern.ch/event/879915/
20. N-jettiness measurement plans, SMP-VJ: Vector Boson Plus Jets meeting, (6 Dec 2019, https://indico.cern.ch/event/861704/