

ALLEGATO B

UNIVERSITÀ DEGLI STUDI DI MILANO

selezione pubblica per n. 1 posto/i di Ricercatore a tempo determinato ai sensi dell'art.24, comma 3, lettera b) della Legge 240/2010 per il settore concorsuale 02/A1, settore scientifico-disciplinare FIS/01 - FIS/04, presso il Dipartimento di Fisica "Aldo Pontremoli", (avviso bando pubblicato sulla G.U. n. 53 del 05/07/2019) Codice concorso 4131

Simone Bifani

CURRICULUM VITAE

INFORMAZIONI PERSONALI

COGNOME	BIFANI
NOME	SIMONE
DATA DI NASCITA	23/01/1979

Curriculum Vitae

I am deeply interested in exploring the precision frontier of physics. I joined the LHCb experiment in 2010 and focussed my work on electroweak physics, rare b -hadron decays and lepton universality. I was responsible for the measurements of W and Z boson production during Run-1 and I co-convoked the “*Electroweak*” sub-working group for two years. I tested lepton universality using $B^0 \rightarrow K^{*0} \ell^+ \ell^-$ decays and I co-convoked the “*Electroweak Penguin Decays*” sub-working group for one year. I am currently working on multi-channel tests of lepton universality using $b \rightarrow s \ell^+ \ell^-$ transitions and co-convoking the “*Rare Decays*” working group. As a member of the NA48 and NA62 collaborations between 2002 and 2009, I made extensive studies of rare kaon decays: I performed original analyses of the $K_{S,L} \rightarrow \pi^\mp \mu^\pm \nu$ and $K^\pm \rightarrow \pi^\pm \gamma \gamma$ processes and contributed to the operation and maintenance of the detector. I published more than 500 journal articles with 3 different international collaborations.

Employments

Senior Research Fellow in Particle Physics: since February 2013

University of Birmingham, School of Physics and Astronomy – Birmingham (United Kingdom)

I am working on multi-channel tests of lepton universality using $b \rightarrow s \ell^+ \ell^-$ transitions and angular analysis of $B^0 \rightarrow K^{*0} e^+ e^-$ decays. I performed the first test of lepton universality using $B^0 \rightarrow K^{*0} \ell^+ \ell^-$ decays at a pp collider, which attracted the attention of the physics community at large as exhibiting a $\sim 2.5\sigma$ tension with the SM that fits in the so-called “flavour anomalies”. I performed the first measurements of forward W and Z production cross-sections in pp collisions at $\sqrt{s} = 8\text{ TeV}$, both inclusive and in association with jets, which significantly improved our understanding of the proton PDFs. I co-supervised three PhD students.

Postdoctoral Researcher in Particle Physics: January 2010 – December 2012

University College Dublin, School of Physics – Dublin (Ireland)

I performed the first measurement of forward W production cross-section in pp collisions at $\sqrt{s} = 7\text{ TeV}$, as well as contributed to the $Z \rightarrow \mu^+ \mu^-$, $Z \rightarrow e^+ e^-$ and $Z \rightarrow \tau^+ \tau^-$ analyses, which had a significant impact on our understanding of the proton PDFs. I co-supervised five PhD students.

FLAVIANet Marie-Curie Early Stage Researcher: January 2008 – December 2009

Albert Einstein Centre for Fundamental Physics, Institute for Theoretical Physics – Bern (Switzerland)

I finalised the analysis of the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ decay that I started during my PhD. I assisted and optimised the collection and reprocessing of the data. I co-supervised one CERN Summer Student.

PRIN Fixed-Term Contract: April – December 2007

University of Torino, Experimental Physics Department – Torino (Italy)

I developed a GEANT4-based simulation tool to study the feasibility and the performance of a novel silicon-pixel spectrometer, GigaTracker, that works with very high rate particle-beams. My results have been used for the initial design of the detector.

Education

Doctor of Philosophy in Physics: 28th March 2008

University of Torino, Experimental Physics Department – Torino (Italy), February 2005 – March 2008

Thesis: “*Study of the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ decay at the NA48/2 experiment*”

I performed the first analysis of the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ decay using in-flight kaon decays. I measured a model independent branching fraction and extracted the Chiral Perturbation Theory coupling constant, $\hat{c}$, with the best precision to date.

Physics Degree Cum Laude: 23rd July 2004

University of Perugia, Physics Department – Perugia (Italy), September 1998 – July 2004

Thesis: “*Study of the $K_{S,L} \rightarrow \pi^\mp \mu^\pm \nu$ decay at the NA48/1 experiment*”

I performed the first analysis of the $K_{S,L} \rightarrow \pi^\mp \mu^\pm \nu$ decay. I measured a preliminary branching fraction.

Professional Experience

Co-Convener of the LHCb “Rare Decays” Working Group (~100 physicists): since January 2018

Member of the UK CERN Fellowship Panel: since January 2018

Representative of the Research Associates of the Particle Physics Group: University of Birmingham – Birmingham (United Kingdom), since December 2017

Internal Reviewer of the LHCb Publications: since February 2013

Co-Convener of the LHCb “Electroweak Penguin Decays” Sub-Working Group (~50 physicists): January – December 2017

Co-Convener of the LHCb UK Student Meetings: May 2014 – April 2015

Co-Convener of the LHC “W/Z Cross-Sections and Distributions” Sub-Working Group: March 2012 – September 2017

Co-Convener of the LHCb “Electroweak” Sub-Working Group (~20 physicists): January 2012 – December 2013

Co-Chair of the “Rare Decays” session of the II Workshop “UK Flavour”: Institute for Particle Physics Phenomenology – Durham (United Kingdom), 4th – 6th September 2017

Co-Convener of the “Forward Electroweak Physics, Including pA” Stream of the IV Workshop “Implications of LHCb Measurements and Future Prospects”: CERN – Geneva (Switzerland), 15th – 17th October 2014

Member of the Programme Committee of the II Workshop “Towards the Ultimate Precision in Flavour Physics”: Institute for Particle Physics Phenomenology – Durham (United Kingdom), 2nd – 4th April 2019

Member of the Programme Committee of the I Workshop “Towards the Ultimate Precision in Flavour Physics”: University of Warwick – Warwick (United Kingdom), 16th – 18th April 2018

Member of the Local Organising and Programme Committee of the XXV International Workshop “Deep Inelastic Scattering and Related Topics”: University of Birmingham – Birmingham (United Kingdom), 3rd – 7th April 2017

Member of the Local Organising Committee of the VI International Workshop “Chiral Dynamics”: Albert Einstein Centre for Fundamental Physics – Bern (Switzerland), 6th – 10th July 2009

Administrator of the Computing Resources of the NA48 and NA62 Experiments: CERN – Geneva (Switzerland), January – December 2009

Supervisor of the Central Data Recording System of the NA62 Experiment: CERN – Geneva (Switzerland), June – September 2007, September – October 2008

Online Monitoring and Hardware Maintenance of the NA48/2 and NA62 Experiments: CERN – Geneva (Switzerland), 2003 – 2008

Grants and Awards

IPPP Senior Experimental Fellowship *“Towards the Ultimate Precision in Flavour Physics”*: 2017 – 2018

Institute for Particle Physics Phenomenology – Durham (United Kingdom)

Co-Investigator for the area *“B Decays to Rare Leptonic and Semileptonic Final States”*

Labex P2IO “Émilie du Châtelet” Programme: October 2016 – January 2017; October, December 2017

Laboratoire de l’Accélérateur Linéaire – Orsay (France)

Visiting Researcher

STFC Long Term Attachment: April 2014 – March 2015

CERN – Geneva (Switzerland)

INFN PhD Scholarship: September 2005 – March 2007

University of Torino, Experimental Physics Department – Torino (Italy)

Project: *“Development and simulation of a silicon spectrometer for the NA62 experiment that works with high rate particles beams”*

INFN Post-Graduate Scholarship: June 2005 (declined)

INFN Post-Graduate Scholarship: January – July 2005

University of Perugia, Physics Department – Perugia (Italy)

Project: *“Study of the systematic uncertainties in the measurement of the $K_S \rightarrow \pi^\mp \mu^\pm \nu$ branching fraction at the NA48/1 experiment”*

CERN Summer Student Programme: July – August 2002

CERN, Physics Department – Geneva (Switzerland)

Project: *“Study of $K_S \rightarrow e^+ e^- \gamma$ decay channel and its normalisation channel $K_S \rightarrow \pi^0 \pi_D^0$ ”*

Teaching

Demonstrator of the 1st year Computing Undergraduate Laboratory

University of Birmingham – Birmingham (United Kingdom), September – December 2018

Introductory Lecture on “Lepton Universality Violation” at YETI School

Institute for Particle Physics Phenomenology – Durham (United Kingdom), 7th – 10th January 2018

Demonstrator of the 1st year Computing and Physics Undergraduate Laboratories

University of Birmingham – Birmingham (United Kingdom), September – December 2013

Demonstrator of the 4th year “High Energy Particle Physics” Undergraduate Course

University College Dublin – Dublin (Ireland), September – December 2010, 2011

Co-Supervisor of eight PhD Students

University of Birmingham – Birmingham (United Kingdom), since April 2013

University College Dublin – Dublin (Ireland), September 2010 – December 2012

Co-Supervisor of one Summer Student

CERN – Geneva (Switzerland), June – August 2008

Conferences

XVI Incontri di Fisica della Alte Energie

Trieste (Italy), 19th – 21st April 2017

Talk: *“Search for new physics with $b \rightarrow s \ell^+ \ell^-$ decays at LHCb”*

LII Rencontres de Moriond on Electroweak Interactions and Unified Theories

La Thuile (Italy), 18th – 25th March 2017

Talk: “Status of new physics searches with $b \rightarrow s \ell^+ \ell^-$ transitions at LHCb”

XXXVIII International Conference on High Energy Physics

Chicago, IL (United States), 3rd – 10th August 2016

Talk: “Rare leptonic and semileptonic b -hadron decays and tests of lepton flavour universality at LHCb”

VII pp@LHC

Pisa (Italy), 16th – 18th May 2016

Talk: “Top physics”

II Annual Conference on Large Hadron Collider Physics

New York, NY (United States), 2nd – 7th June 2014

Talk: “Electroweak physics at LHCb”

XIII International Conference on Meson-Nucleon Physics and the Structure of the Nucleon

Rome (Italy), 30th September – 4th October 2013

Talk: “PDF studies at LHCb”

XI Conference on the Intersection of Particle and Nuclear Physics

St. Petersburg, FL (United States), 29th May – 3rd June 2012

Talk: “Measurement of W and Z production in the forward region with LHCb”

XXIII Rencontres de Blois

Blois, Loire Valley (France), 29th May – 3rd June 2011

Talk: “Electroweak and QCD studies in the forward region with LHCb”

XVII International Conference on Supersymmetry and the Unification of Fundamental Interactions

Boston, MA (United States), 5th – 10th June 2009

Talk: “Standard Model tests at the NA62 CERN experiment”

XIV International Symposium on Particles, Strings and Cosmology

Waterloo (Canada), 2nd – 6th June 2008

Talk: “Low energy QCD and Chiral Perturbation Theory tests at the NA48/2 experiment”

XCIII National Congress of the Italian Physical Society

Pisa (Italy), 24th – 29th September 2007

Talk: “Study of the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ decay at the NA48/2 experiment”

XXI Conference on New Trends in High Energy Physics

Yalta (Ukraine), 15th – 22nd September 2007

Talk: “Low energy QCD and Chiral Perturbation Theory tests at the NA48/2 experiment”

VI Latin American Symposium on High Energy Physics

Puerto Vallarta (Mexico), 1st – 8th November 2006

Talk: “Recent results from the NA48/2 experiment at CERN/SPS”

XCII National Congress of the Italian Physics Society

Torino (Italy), 18th – 23rd September 2006

Talk: “Study of the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ decay at the NA48/2 CERN experiment”

XC National Congress of the Italian Physics Society

Brescia (Italy), 20th – 25th September 2004

Talk: “Study of the $K_{S,L} \rightarrow \pi^\mp \mu^\pm \nu$ decay at the NA48/1 experiment”

Workshops

VII Workshop on Implications of LHCb Measurements and Future Prospects

Geneva (Switzerland), 8th – 10th November 2017

Talk: “Experimental overview of $b \rightarrow s \ell^+ \ell^-$ decays”

PDF4LHC

Geneva (Switzerland), 3rd November 2014

Talk: “W production at LHCb”

LHCb Workshop on Quantum Interference Effects, QCD Measurements and Generator Tuning

Geneva (Switzerland), 20th – 22nd October 2014

Talk: “Electroweak and QCD measurements at LHCb”

EW Precision Physics at the LHC

Geneva (Switzerland), 30th June – 1st July 2014

Talk: “LHCb report”

Electroweak Precision Measurements at the LHC

Geneva (Switzerland), 28th – 30th November 2011

Talk: “LHCb: status of the electroweak analyses”

QCD@LHC 2011

St. Andrews (United Kingdom), 22nd – 26th August 2011

Talk: “W and Z production at LHCb”

EuroFlavour 2009

Bari (Italy), 9th – 11th November 2009

Talk: “Recent results from the NA48/NA62 CERN experiments”

EuroFlavour 2008

Durham (United Kingdom), 22nd – 26th September 2008

Talk: “Chiral Perturbation Theory tests at the NA48/2 experiment”

IV INFN Torino Congress

Torino (Italy), 23rd January 2007

Talk: “Recent results from the NA48/2 experiment at CERN/SPS”

Seminars

Centre de Physique des Particules de Marseille

Marseille (France), 29th January 2018

Séminaire: “Is lepton universality violated in B decays?”

University of Oxford

Oxford (United Kingdom), 28th November 2017

EPP Seminar: “Tests of lepton universality at LHCb”

University of Warwick

Warwick (United Kingdom), 23th November 2017

EPP Seminar: “Tests of lepton universality at LHCb”

University of Birmingham

Birmingham (United Kingdom), 18th October 2017

PP Seminar: “Flavour anomalies at LHCb”

Institute for Particle Physics Phenomenology

Durham (United Kingdom), 30th June 2017

IPPP Seminar: “Search for new physics with $b \rightarrow s \ell^+ \ell^-$ decays at LHCb”

University of Liverpool

Liverpool (United Kingdom), 28th June 2017

HEP Seminar: “Search for new physics with $b \rightarrow s \ell^+ \ell^-$ decays at LHCb”

Laboratoire de l’Accélérateur Linéaire

Orsay (France), 6th June 2017

Séminaire Général: “Search for new physics with $b \rightarrow s \ell^+ \ell^-$ decays at LHCb”

Albert Einstein Centre for Fundamental Physics

Bern (Switzerland), 24th May 2017

Plenary Meeting: “Search for new physics with $b \rightarrow s \ell^+ \ell^-$ decays at LHCb”

CERN

Geneva (Switzerland), 18th April 2017

LHC Seminar: “Search for new physics with $b \rightarrow s \ell^+ \ell^-$ decays at LHCb”

Schools

XVII Detectors School

Torino (Italy), 27th February – 2nd March 2007

XVI Detectors School

Torino (Italy), 27th February – 3rd March 2006

CLXIII Course of the International School of Physics “Enrico Fermi” of the Italian Physical Society

Varenna (Italy), 19th – 29th July 2005

X LNF Spring School “Bruno Touschek” in Nuclear, Subnuclear and Astroparticle Physics

Frascati (Italy), 16th – 20th May 2005

Computing

Applications: L^AT_EX, MATHEMATICA, MATLAB, OFFICE, ROOT

Collaborative Tools: GIT, SVN, MATTERMOST, SLACK

Systems: LINUX, MAC OS X, WINDOWS, administrator of small and medium-sized clusters

Programming: C, C++, FORTRAN, PYTHON, SHELL SCRIPTING

Technical Training Course: “C++ for Particle Physicists”, CERN – Geneva (Switzerland), 6th – 10th March 2006

Languages

Italian: first language

English: fluent

French: good comprehension

Skills

High-level analytical capability

Creative approach to problem solving

Ability to apply relevant models, techniques and methods and develop new ones

Verbal and written communication skills

Collaborative work, organisation of meetings and production of reports

Activity Report

At present, there are profound experimental and theoretical indications that the Standard Model (SM) is not complete as a theory of elementary particles. The very resilience shown to date tells us that whatever lies Beyond the SM (BSM) must be subtle in nature, making its search challenging and very exciting. Experiments are progressing with constantly advanced technologies, but the ground to cover is vast and a broad experimental programme is the key to improve our understanding of nature. Precision studies are a powerful probe for BSM physics in a complementary way to direct searches, and are crucial to correctly identify its nature as well as understand its theoretical consequences.

I am deeply interested in exploring the precision frontier of physics and I played central roles in diverse aspects of the physics programmes of three international collaborations based at CERN. My entire career has been focussed on improving the precision of measurements in the electroweak sector, and looking for deviations from predictions in rare K meson and b -quark hadron decays that can address, indirectly, energy scales even beyond those accessible at present colliders.

NA48 and NA62 Experiments (2002-2009)

Master's Degree – University of Perugia (1998-2004)

I joined the NA62, formerly NA48, experiment as a CERN Summer Student in 2002. My very first analysis involved the study of the $K_S \rightarrow e^+e^-\gamma$ radiative rare decay, which provides key information on the vertex form-factor that is of great interest for the study of the $K_S \rightarrow e^+e^-$ very rare decay.

As a graduate student at the University of Perugia, I studied the $K_{S,L} \rightarrow \pi^\mp \mu^\pm \nu$ semi-leptonic decay that allows to test the validity of the $\Delta S = \Delta Q$ selection rule and look for CP violation. Due to the interference between K_S and K_L , results were extracted by fitting the decay rate as a function of the decay position. I designed and optimised the event selection and background rejection, and measured from data the production asymmetry between K^0 and $\bar{K}^0$, which is known up to a quadratic ambiguity caused by the undetected neutrino. Using approximately one third of the data collected by the NA48/1 experiment during 2002, I obtained a preliminary result of the $K_S \rightarrow \pi^\mp \mu^\pm \nu$ branching fraction with a statistical precision of about 4%. The muon reconstruction and selection techniques that I developed, as well as the tuning of the simulation response, have been adopted in the analysis of the $\Xi^0 \rightarrow \Sigma^+ \mu^- \bar{\nu}_\mu$ decay [1].

PhD – University of Torino (2005-2008)

While pursuing my PhD at the University of Torino, I studied the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ radiative rare decay. Radiative non-leptonic decays of kaons provide fundamental tests of the description of low-energy weak-processes by Chiral Perturbation Theory (χPT). Within this framework, the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ decay is described by two non-interfering contributions: the first accounts for the pion and kaon loop-amplitudes and depends on an unknown parameter, $\hat{c}$, while the second takes into account the pole term. Due to the dominance of the pion loop-amplitude, the di-photon invariant mass spectrum exhibits a distinctive cusp-like structure at twice the charged pion mass. I performed the full validation of the simulation response for charged tracks and photons using the more abundant $K^\pm \rightarrow \pi^\pm \pi^0$ decay, which is also adopted as normalisation channel since having the same topology of the signal. This validation includes the correction for the small, residual, magnetic field in the vacuum tank and mis-calibration of the magnetic field in the spectrometer, as well as for the non-linear response of the calorimeter readout and cluster reconstruction that exploits the projective structure of the calorimeter cells. I designed and optimised the event selection and background rejection, in particular, the reduction of decays where two photons overlap at the electromagnetic calorimeter and are reconstructed as a unique, coalescent,

cluster. The total signal efficiency is about 12%, with a S/B ratio of 3.5%. Using the data collected by the NA48/2 experiment during 2003, I measured the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ branching fraction with a precision of approximately 4%. This allowed the determination of the χPT parameter $\hat{c}$ with a precision of about 14%. Preliminary results of this measurement have been presented at international conferences^[1]. My studies on the background contamination and the determination of the trigger efficiency have been used in the analysis of the $K^\pm \rightarrow \pi^\pm \pi^0 \gamma$ decay [2].

Additionally, I developed a GEANT4-based simulation tool to study the feasibility and the performance of a novel silicon-pixel spectrometer, GigaTracker, that works with very high rate particle-beams. This sub-detector should track every particle of the 75 GeV/c hadron beam of the NA62 experiment at a rate of about 1 GHz with a time resolution of ~ 100 ps, and provide good momentum and angle resolution. My results have been used for the initial design of the GigaTracker [3].

Throughout my PhD I helped in the operation of the trigger system and monitored the efficiency of the photon-veto sub-detector during test runs in 2005 and 2006, as well as during the NA62 data taking in 2007. For the latter, I also designed the online software-selection of the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ decay on which Ref. [4] is based.

Marie-Curie Early Stage Researcher – Albert Einstein Centre for Fundamental Physics (2008-2009)

As a Marie-Curie Early Stage Researcher at the Albert Einstein Centre for Fundamental Physics within the FLAVIANet european training network, I extended the analysis of the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ decay to the full NA48/2 data set (2003+2004), implemented a fit to the di-photon invariant mass spectrum to extract the χPT parameter $\hat{c}$ and completed the study of the systematic uncertainties. Unfortunately, I identified a source of significant bias, which was caused by the online trigger being optimised to select $K^\pm \rightarrow \pi^\pm \pi^0 \gamma$ events, that prevented the result from being published. However, the strategy and methods that I developed have been later adopted to analyse a minimum-bias sample that resulted in Ref. [5]. The same techniques were also used in Ref. [4], which fully exploits the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ online software-selection that I designed for the 2007 data taking. These two publications represent the most precise study of the $K^\pm \rightarrow \pi^\pm \gamma \gamma$ decay to date.

In addition, besides being in charge of the operation and monitoring of several sub-detectors, I supervised the collection and processing of the data. Specifically, I optimised the systems running the online software-selection and the reprocessing of the data to apply new, more precise, detector calibrations. The tools I set up were also used for the data acquisition during dedicated test runs [6].

LHCb Experiment (2010-Present)

Postdoctoral Researcher – University College Dublin (2010-2012)

I joined the LHCb collaboration in 2010 in the capacity of Postdoctoral Researcher at the University College Dublin and focussed my work on studying electroweak boson production. Measurements of the W and Z boson cross-sections constitute an important test of the SM at the LHC energies, and the forward acceptance of the LHCb detector provides unique data that can improve our knowledge of the proton Parton Density Functions. I am the main author of the first measurement of the inclusive $W \rightarrow \mu \nu$ production cross-section in pp collisions at $\sqrt{s} = 7$ TeV in the forward region and I contributed to the $Z \rightarrow \mu^+ \mu^-$ analysis [7]. For these two analyses I developed a number of signal and control trigger lines, optimised the offline selection criteria, designed original data-driven methods for the determination of the background contaminations and reconstruction efficiencies. Furthermore, I contributed to the $Z \rightarrow e^+ e^-$ [8] and $Z \rightarrow \tau^+ \tau^-$ [9] analyses, the first ones using electrons and taus at LHCb, with

¹S.Bifani, talk on “Low energy QCD and χPT tests at the NA48/2 experiment” at the XIV International Symposium on Particles, Strings and Cosmology – Waterloo (Canada), 2-6 June 2008.

efficiency and background studies. I presented these results at several international conferences and workshops²

In recognition of my work I was appointed co-convenor of the *LHCb “Electroweak”* sub-working group, which consists of around 20 physicists at various levels of experience (from PhD student to senior physicists), a position that I held for two years (2012-2013). In this capacity I followed all the activities of the group, facilitated analyses and guaranteed the best quality of the produced results. During my appointment, further results on W and Z boson production beside the measurements previously discussed have been published [10,11]. Additionally, I was appointed co-convenor of the *LHC “W/Z Cross-Sections and Distributions”* sub-working group with the purpose of defining common strategies to ease the comparison and combination of W and Z measurements from the LHC experiments, and maximise their impact on theory predictions. During my appointment, a procedure to extrapolate the results among the ATLAS, CMS and LHCb experiments has been published [12].

Senior Research Fellow – University of Birmingham (2013-Present)

As a Senior Research Fellow at the University of Birmingham I continued working on electroweak physics. The extensive expertise that I developed on the subject allowed me to publish several results in a relatively short amount of time. I am the main author of the LHCb legacy measurements of the inclusive W and Z production cross-section in pp collisions at $\sqrt{s} = 7$ TeV [13,14] and 8 TeV [15], which include world-leading determinations of ratios of production cross-sections. I contributed to the measurement of the inclusive $W \rightarrow e\nu$ production cross-section in pp collisions at $\sqrt{s} = 8$ TeV [16], which, in combination with the $W \rightarrow \mu\nu$ result, allows tests of Lepton Universality (LU) to be made with a precision comparable to the combined LEP result. I also worked on the measurement of W and Z production in association with jets [17], which constrains the proton PDFs and tests higher-order effects in pQCD. Finally, I contributed to the first measurement of the inclusive $Z \rightarrow \mu^+\mu^-$ production cross-section in pp collisions at $\sqrt{s} = 13$ TeV [18].

At the same time, I started studying rare b -hadron decays, specifically $b \rightarrow s \ell^+\ell^-$ Flavour-Changing Neutral-Current (FCNC) transitions. Such processes are forbidden at first order in the SM and proceed through electroweak loop (penguin and box) diagrams. In the presence of BSM physics these transitions may receive significant contributions from new unobserved particles, such as a Z' boson or leptoquarks, which can enhance or suppress their decay rate, introduce new sources of CP violation or modify the angular distribution of the final-state particles.

Rare decays of b -baryons are less explored compared to B mesons, but offer complementary information that are crucial to understand the structure of the underlying theory. The study of $\Lambda_b^0 \rightarrow \Lambda \mu^+\mu^-$ is of considerable interest because the Λ_b^0 baryon has non-zero spin, the hadronic physics differs significantly from that of B -meson decays, and the polarisation of the Λ baryon is preserved in its decay to $p\pi$. I contributed to the design and optimisation of the Neural-Network classifier used for discriminating signal from background and to the efficiency modelling of the $\Lambda_b^0 \rightarrow \Lambda \mu^+\mu^-$ angular analysis [19]. This result represents the first observation of such decay in the region of di-muon invariant mass below the J/ψ resonance and allowed the angular distributions to be studied. Specifically, the forward-backward asymmetries in the di-muon and hadron systems have been measured for the first time, reinvigorating the interest in rare b -baryon decays in the context of searches for BSM physics.

While finalising the $\Lambda_b^0 \rightarrow \Lambda \mu^+\mu^-$ angular analysis, I started testing LU using $B^0 \rightarrow K^{*0} \ell^+\ell^-$ decays. In the SM, due to the equality of the electroweak couplings of gauge bosons to leptons, the decay rates of processes whose final states only differ by the flavour of the participating leptons are expected to be the same (except for very small Higgs-penguin contributions and difference in phase-space due to the lepton masses). In particular, ratios of branching fractions represent a powerful test of LU as theoretical uncertainties largely cancel and experimental systematics are much reduced. The LHCb

²S.Bifani, talk on “Measurement of W and Z production in the forward region with LHCb” at the XI Conference on the Intersection of Particle and Nuclear Physics – St. Petersburg, FL (United States), 29 May - 3 June 2012.

collaboration has measured this type of ratio in the exclusive $B^+ \rightarrow K^+ \ell^+ \ell^-$ decay, R_K , with a precision of about 13% [20]. The result manifests a tension with the SM expectation of about 2.6 standard deviations and attracted the attention of the physics community at large because of similar anomalies in other $b \rightarrow s \ell^+ \ell^-$ modes [21]. The experimental environment in which the LHCb detector operates leads to significant differences in the treatment of decays involving muons or electrons. Specifically, the much higher bremsstrahlung rate by the latter and the different trigger thresholds due to the higher occupancy of the calorimeters than the muon stations, lead to a difference in the reconstruction efficiency of about a factor five in favour of the muon modes. As a result, the tuning of the simulation response, which is typically performed using data-driven techniques on control samples, represents a key aspect of these analyses. I spent a four month secondment at the Laboratoire de l'Accélérateur Linéaire (Orsay) where I designed and optimised the full procedure to tune the modelling of the decay kinematics, the particle identification and trigger response, as well as the description of the event reconstruction. I developed various techniques that allow cross-validation of the results and implemented methods to reduce biases. In particular, a Gradient-Boosting tool to minimise differences in multidimensional distributions between data and simulation. The control of the absolute scale of the efficiency corrections was tested by measuring the $\mathcal{B}(B^0 \rightarrow K^{*0} J/\psi (\rightarrow \mu^+ \mu^-)) / \mathcal{B}(B^0 \rightarrow K^{*0} J/\psi (\rightarrow e^+ e^-))$ ratio and similar quantities involving $B^0 \rightarrow K^{*0} \psi(2S) (\rightarrow \ell^+ \ell^-)$ and $B^0 \rightarrow K^{*0} \gamma$ (with a photon conversion to an electron pair in the detector material) decays. All these cross-checks were found to be consistent with the SM expectation. Moreover, I performed a detailed background study by means on Neural-Network classifiers and optimised the muon and electron selections to ensure that no biases are introduced. The test of LU in the exclusive $B^0 \rightarrow K^{*0} \ell^+ \ell^-$ decay, $R_{K^{*0}}$, has been performed in two regions of the di-lepton invariant mass with a precision of about 18% [22]. The measurements manifest a tension with the SM expectation of 2.1 – 2.5 standard deviations. I am the main author of this analysis and I was the first to present the results at a dedicated LHC seminar³ at CERN. Thereafter, I co-wrote a feature article [23] on the CERN Courier about the present B anomalies as well as a review of LU tests in B decays [24] that has been published by the Journal of Physics G.

In recognition of my work and leadership I was appointed co-convenor of the LHCb “*Electroweak Penguin Decays*” sub-working group, which consists of around 50 physicists at various levels of experience (from PhD student to senior physicists), starting from January 2017. In December 2017, I was appointed co-convenor of the LHCb “*Rare Decays*” working group, one of the largest and most active in LHCb. I took up this two-year appointment starting from January 2018. At present, I am working and coordinating a multi-channel test of LU based on $b \rightarrow s \ell^+ \ell^-$ transitions in LHCb that exploits state-of-the-art machine-learning techniques to further discriminate signal from backgrounds and improve the electron reconstruction efficiency.

³S.Bifani, LHC seminar on “*Search for new physics with $b \rightarrow s \ell^+ \ell^-$ decays at LHCb*” at CERN – Geneva (Switzerland), 18 April 2017.

Student Supervision, Teaching and Work Coordination

Throughout the years I have been involved in co-supervising students at different stages of their education process: one CERN Summer Student while working in the NA62 experiment, five PhD students at the University College Dublin, and three PhD students at the University of Birmingham, with many continuing in the field after graduation.

CERN Summer Student	% of Supervision	Current Position
Dr. Elisa Papa	80%	Privacy Expert at Deloitte Switzerland
University College Dublin	% of Supervision	Current Position
Dr. James Keaveney	40%	Lecturer at University of Cape Town
Dr. Stephen Farry	40%	Research Associate at University of Liverpool
Dr. Philip Ilten	20%	University Fellow at University of Birmingham
Dr. Wenchao Zhang	80%	Associate Professor at Shaanxi Normal University
Dr. Ronan Wallace	60%	Research Scientist at Amazon
University of Birmingham	% of Supervision	Current Position
Dr. Luca Pescatore	80%	Consultant at Argusa Sarl
Georgios Chatzikonstantinidis	40%	PhD Student
Ryan Calladine	80%	PhD Student

While at the University College Dublin I have supervised the fourth year “*High Energy Particle Physics*” undergraduate course projects, and while at the University of Birmingham I have served as demonstrator of the hands-on sessions of the first year computing and physics undergraduate laboratories. Moreover, I have been personally invited to give an introductory lecture on “*Lepton Universality Violation*” at the 2018 YETI school^[4] and an overview lecture on “*Experimental Tests of Lepton Flavour Universality*” at the 2019 SLAC Summer Institute^[5].

In the capacity of co-convenor of various LHCb working groups I organise and chair meetings, schedule and manage work of others, and coordinate and review analyses. At the University of Birmingham, I give substantial help to the team leader, Nigel Watson, in the management and organisation of the local LHCb group (four staff and four PhD students) by organising weekly meetings, supervising students and preparing grant applications for both the Particle Physics group and the LHCb-UK community. Furthermore, I am the representative of the Research Associates of the Particle Physics group and member of the UK CERN Fellowship Panel.

Conferences, Workshops and Seminars

I have given talks at various, high profile, international conferences (Moriond EW in 2017, ICHEP in 2016, LHCP in 2014, CIPANP in 2012 and SUSY in 2009) and workshops, either personally invited or on behalf of the collaborations I worked in, and I have also given invited seminars at various institutes in Europe.

I have been a member of the organising and programme committees of several international conferences and workshops, such as the “*VI International Workshop on Chiral Dynamics*”^[6] the “XXV

⁴YETI 2018 “*Flavours and resonances: what has the LHC done for us?*”, Institute for Particle Physics Phenomenology – Durham (United Kingdom), 7-10 January 2018.

⁵2019 SLAC Summer Institute “*Menu of Flavors: Quarks, Charged Leptons & Neutrinos*”, SLAC National Accelerator Laboratory – Menlo Park, CA (United States), 12-23 August 2019.

⁶VI International Workshop on Chiral Dynamics – Bern (Switzerland), 6-10 July 2009.

International Workshop on Deep Inelastic Scattering and Related Topics⁷ and the two workshops “Towards the Ultimate Precision in Flavour Physics”⁸ as well as co-convener of the “Forward Electroweak Physics, Including pA ” stream of the “IV Workshop on Implications of LHCb Measurements and Future Prospects”⁹

Grants and Awards

During my studies I have received three academic awards: one CERN Summer Studentship, and two competitively based from INFN. Upon invitation, I received an “Émilie du Châtelet” grant from the Laboratoire d’Excellence Physique des 2 Infinis et des Origines to spend four months as a visiting researcher at the Laboratoire de l’Accélérateur Linéaire (Orsay) in 2016. During this secondment, which was extended for two extra months in 2017, I finalised the test of LU using $B^0 \rightarrow K^{*0} \ell^+ \ell^-$ decays. Finally, I am the co-investigator for the area “ B Decays to Rare Leptonic and Semileptonic Final States” of the 2017-2018 IPPP Senior Experimental Fellowship¹⁰

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⁷XXV International Workshop on Deep Inelastic Scattering and Related Topics – Birmingham (United Kingdom), 3-7 April 2017.

⁸I Workshop “Towards the Ultimate Precision in Flavour Physics” – University of Warwick (United Kingdom), 16 - 18 April 2018; II Workshop “Towards the Ultimate Precision in Flavour Physics” – Institute for Particle Physics Phenomenology - Durham (United Kingdom), 2 - 4 April 2019.

⁹IV Workshop on Implications of LHCb Measurements and Future Prospects – CERN (Switzerland), 15-17 October 2014.

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Data

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