ROMA TRE
UNIVERSITÀ DEGLI STUDI

PROCEDURA PUBBLICA DI SELEZIONE PER L'ASSUNZIONE DI N.1 RICERCATORE A TEMPO DETERMINATO AI SENSI DELL'ART.24, COMMA 3, LETT. A) DELLA LEGGE 240/2010 PER IL SETTORE CONCORSUALE 02/A2 - SETTORE SCIENTIFICO DISCIPLINARE FIS/02 - FISICA TEORICA, MODELLI E METODI MATEMATICI - DIPARTIMENTO DI MATEMATICA E FISICA - UNIVERSITA' ROMA TRE.

VERBALE N. 2
(Valutazione preliminare dei candidati)

Il giorno 14 Luglio 2017 alle ore 8:30 si è riunita presso il Dipartimento di Matematica e Fisica la Commissione giudicatrice della suddetta selezione, nominata con D.R. n.397-2017 del 7 Aprile 2017, nelle persone di:

Prof. Vittorio Lubicz

Prof. Ferruccio Feruglio

Prof. Andrea Romanino

La Commissione, accertato che i criteri generali fissati nella precedente riunione sono stati resi pubblici per almeno sette giorni, inizia la verifica dei nomi dei candidati e tenendo conto dell'elenco fornito dall'Amministrazione dichiara di non avere relazioni di parentela ed affinità entro il 4° grado incluso con gli stessi (art. 5 comma 2 D.lgs. 07.05.1948 n.1172).

La Commissione, presa visione dell'elenco dei candidati alla selezione trasmesso dall'Amministrazione, delle pubblicazioni effettivamente inviate e della rinuncia sino ad ora pervenuta (Dott. Molinaro Emiliano) decide che i candidati da valutare ai fini della selezione sono n. 3 e precisamente:

1) Gross Christian
2) Mazzeo Marco Domenico
3) Panizzi Luca

e come stabilito nella riunione del 25 Maggio 2017, data la loro numerosità inferiore o pari a 6, sono tutti ammessi alla discussione pubblica ed alla valutazione.

La Commissione quindi procede ad aprire i plichi inviati dai candidati e vengono prese in esame, secondo l'ordine alfabetico dei candidati, solo le pubblicazioni corrispondenti all'elenco delle stesse allegato alla domanda di partecipazione al concorso.

La Commissione, ai fini della presente selezione, prende in considerazione esclusivamente pubblicazioni o testi accettati per la pubblicazione secondo le norme vigenti nonché saggi inseriti in opere collettanee e articoli editi su riviste in formato cartaceo o digitale con esclusione di note interne o rapporti dipartimentali. La tesi di dottorato o dei titoli equipollenti sono presi in considerazione anche in assenza delle condizioni di cui al presente comma.

Per la valutazione la Commissione tiene conto dei criteri indicati nella seduta preliminare del 25 Maggio 2017.

FF

Il Presidente ricorda che le pubblicazioni redatte in collaborazione con i membri della Commissione e con i terzi possono essere valutate solo se rispondenti ai criteri individuati nella prima riunione del 25 Maggio 2017.

La Commissione, terminata la fase dell'enucleazione, tiene conto di tutte le pubblicazioni presentate da ciascun candidato, come risulta dagli elenchi dei lavori dei candidati, che vengono allegati al verbale e ne costituiscono parte integrante. (Allegato A)

La Commissione procede poi all'esame dei titoli presentati da ciascun candidato, in base ai criteri individuati nella prima seduta. (Allegato B – Curricula).

La Commissione procede ad effettuare la valutazione preliminare di tutti i candidati con motivato giudizio analitico sui titoli, sul curriculum e sulla produzione scientifica, ivi compresa la tesi di dottorato (Allegato C)

Accertato che è terminata la fase attinente alla redazione dei giudizi analitici relativi ai candidati, che sono uniti al presente verbale come parte integrante dello stesso, (All. C verb. 2), la seduta è sciolta alle ore 11:00 e la Commissione unanime decide di aggiornare i lavori al giorno 14 Luglio 2017 alle ore 11:30 per l'espletamento del colloquio e l'accertamento della conoscenza della lingua straniera.

Il presente verbale è letto, approvato e sottoscritto seduta stante.

Roma, 14 Luglio 2017

LA COMMISSIONE:

Prof. Vittorio Lubicz ______________

Prof. Ferruccio Feruglio ______________

Prof. Andrea Romanino ______________

N.B La Commissione, anziché riportare i titoli dei candidati, può far riferimento ai curricula presentati dagli stessi.
Questi dovranno essere allegati al presente verbale e siglati in ogni foglio da ciascun componente della Commissione.

ALLEGATO C

Giudizi analitici sui titoli, sul curriculum e sulla produzione scientifica dei candidati:

CANDIDATO: **Christian Gross**

Titoli e curriculum

Il candidato ha conseguito la laurea magistrale in Fisica nel 2006 presso l'Universität di Heidelberg ed il dottorato di ricerca nel 2009 presso l'Universität di Amburgo.
Ha ricoperto posizioni di ricerca post-dottorali presso la Technische Universität di Dortmund (2009-2011), l'Universität di Basel (2011-2014) e l'Università di Helsinki (dal 2014 ad oggi)
Ha tenuto parte di un corso all'Università di Helsinki sulla "Fisica oltre il Modello Standard". Ha svolto attività di tutoraggio per vari corsi, principalmente di Meccanica Quantistica e Teoria dei Campi.
Ha preso parte come relatore a numerosi convegni internazionali.

La commissione giudica ottimo il curriculum del candidato.

Produzione scientifica

La tesi di dottorato del candidato si è incentrata sullo studio di modelli inflazionari in teorie di stringa.
La sua attività scientifica è testimoniata da un'ottima produttività ed ha interessato un ampio spettro di argomenti della Fisica Teorica, dalla teoria delle stringhe, alla fisica del flavor, alla supersimmetria, alle Teorie di Grande Unificazione e alla fisica della materia oscura. Le pubblicazioni hanno avuto un ottimo impatto nei settori di ricerca coinvolti.

La commissione giudica la produzione scientifica del candidato ottima.

Giudizio complessivo

Il giudizio complessivo sul candidato è ottimo.

FF

CANDIDATO: **Mazzeo Marco Domenico**

Titoli e curriculum

Il candidato ha conseguito la laurea in Fisica nel 2003 presso l'Università di Bologna e il dottorato di ricerca nel 2009 presso l'University College London (UCL), UK.
Ha ricoperto una posizione di ricerca post-dottorale presso l'Universidad Pompeu Fabra di Barcellona negli anni 2009-2012.
Al momento si dichiara "Freelance physicist, researcher, teacher and consultant" nella città di Bologna.
Non risulta aver preso parte a convegni nazionali o internazionali di interesse per il settore concorsuale 02/A2.

Il curriculum fa cenno ad una attività didattica come "Teacher of Physics, Mathematics, Programming and Algorithms".

La commissione giudica sufficiente il curriculum del candidato, con una marginale sovrapposizione tuttavia con gli argomenti di interesse del settore concorsuale 02/A2.

Produzione scientifica

La tesi di dottorato si è incentrata su simulazioni del flusso del sangue nel cervello.
L'attività scientifica è testimoniata da una appena sufficiente produzione nel settore delle simulazioni numeriche del comportamento dei fluidi.

La commissione giudica la produzione scientifica del candidato appena sufficiente e con una marginale sovrapposizione con gli argomenti di interesse del settore concorsuale 02/A2.

Giudizio complessivo

Il giudizio complessivo sul candidato è sufficiente.

CANDIDATO: **Luca Panizzi**

Titoli e curriculum

Il candidato ha conseguito la laurea magistrale in Fisica nel 2005 presso l'Università di Firenze ed il dottorato di ricerca nel 2009 presso l'Università di Trieste.
Ha ricoperto posizioni di ricerca post-dottorali presso l'Institut de Physique Nucléaire de Lyon e CNRS (2009-2012), presso l'Università di Southampton (2012-2016) e presso l'Università di Genova (2016-oggi).
Ha svolto attività didattica come esercitatore per diversi corsi a Southampton (corsi di laboratorio e di Metodi Matematici per le Scienze Fisiche) e Genova (Fisica Generale per Ingegneria).
All'Università di Southampton ha svolto il ruolo di correlatore di una tesi di laurea triennale, di correlatore di 2 tesi di dottorato e di supervisore di 3 studenti di Master dell'ENS di Lione in visita.

Ha ottenuto la "Qualification aux fonctions de maître de confèrences" rilasciato dal "Ministère de l'Education Nationale, de l'Enseignement Supérieur et de la Recherche" in Francia.

Ha preso parte come relatore a numerosi convegni internazionali.

Vanta inoltre una discreta attività di divulgazione della scienza.

La commissione giudica ottimo il curriculum del candidato.

Produzione scientifica

La tesi di dottorato del candidato si è incentrata sullo studio delle correzioni radiative elettrodeboli ai processi di produzione di particelle supersimmetriche (squarks) al LHC. Presenta inoltre una ricca produzione scientifica, principalmente incentrata sull'analisi model-independent di scenari di nuova fisica, ricerca di materia oscura e fisica dei neutrini al LHC.

La commissione giudica la produzione scientifica del candidato ottima.

Giudizio complessivo

Il giudizio complessivo sul candidato è ottimo.

ELENCO DELLE PUBBLICAZIONI PRESENTATE E DELLA TESI DI DOTTORATO

Christian Gross

12 PUBBLICAZIONI PRESENTATE

1.) *G. Arcadi, C. Gross, O. Lebedev, Y. Mambrini, S. Pokorski and T. Toma*
Multicomponent Dark Matter from Gauge Symmetry
JHEP **1612** (2016) 081

2.) *C. Gross, O. Lebedev and M. Zatta*
Higgs-inflaton coupling from reheating and the metastable Universe
Phys. Lett. B **753** (2016) 178

3.) *C. Gross, O. Lebedev and Y. Mambrini*
Non-Abelian gauge fields as dark matter
JHEP **1508** (2015) 158

4.) *A. Falkowski, C. Gross and O. Lebedev*
A second Higgs from the Higgs portal
JHEP **1505** (2015) 057

5.) *S. Antusch, C. Gross, V. Maurer and C. Sluka*
Inverse neutrino mass hierarchy in a flavour GUT model
Nucl. Phys. B **879** (2014) 19

6.) *S. Antusch, C. Gross, V. Maurer and C. Sluka*
A flavour GUT model with $\theta_{13}^{\rm PMNS} = \theta_C/\sqrt{2}$
Nucl. Phys. B **877** (2013) 772

7.) *C. Gross, G. Marques Tavares, M. Schmaltz and C. Spethmann*
Light axigluon explanation of the Tevatron $t\bar{t}$ asymmetry and multijet signals at the LHC
Phys. Rev. D **87** (2013) 014004

8.) *A. Behring, C. Gross, G. Hiller and S. Schacht*
Squark Flavor Implications from $\bar{B} \to \bar{K}^{(*)} l^+ l^-$
JHEP **1208** (2012) 152

9.) *S. Antusch, C. Gross, V. Maurer and C. Sluka*
$\theta_{13}^{\rm PMNS} = \theta_C/\sqrt{2}$ from GUTs
Nucl. Phys. B **866**, 255 (2013)

10.) *C. Gross and A. Hebecker*
A Realistic Unified Gauge Coupling from the Micro-Landscape of Orbifold GUTs
Nucl. Phys. B **821**, 354 (2009)

11.) *L. Covi, M. Gómez-Reino, C. Gross, J. Louis, G. A. Palma and C. A. Scrucca*
Constraints on modular inflation in supergravity and string theory
JHEP **0808**, 055 (2008)

12.) *L. Covi, M. Gómez-Reino, C. Gross, J. Louis, G. A. Palma and C. A. Scrucca*
De Sitter vacua in no-scale supergravities and Calabi-Yau string models
JHEP **0806**, 057 (2008)

TESI DI DOTTORATO

C. Gross
De Sitter vacua and inflation in no-scale string models
PhD thesis, 2009; DESY-THESIS-2009-029
http://www-library.desy.de/preparch/desy/thesis/desy-thesis-09-029.pdf

24.3.17, Christian

Titoli

Diploma del Dottorato di Ricerca in Fisica Computazionale svolto nel dipartimento di Chimica dell'Università di Londra "University College London", UK

Certificato del Dottorato di Ricerca con dettagli e date relative al corso

Certificato del corso di Laurea (vecchio ordinamento) in Fisica, Bologna, comprendente il voto, la lista degli esami svolti ed i punteggi

Diploma della Laurea in Fisica

Tesi del dottorato di ricerca

La tesi è resa disponibile dall'Università di Londra "University College London" al seguente web-link: eprints.ucl.ac.uk/19357

Articoli selezionati e presentati

MDM *Fast discontinuous-Galerkin lattice-Boltzmann simulations on GPUs via maximal kernel fusion*, Comput Phys Commun 184, 2013

MDM *The Spy Element Method – A universal approach to complex computing on manycore processors*, J Comput Sci 3, 2012

RS Saksena, MDM, ... *Petascale lattice-Boltzmann studies of amphiphilic cubic liquid crystalline materials in a globally high-performance computing and visualization environment*, Phil Trans Royal Soc A 368, 2010

MDM, ... *The Linked Neighbour List (LNL) method for fast off-lattice Monte Carlo simulations of fluids*, Comput Phys Commun 181, 2010

MDM, ... *In situ ray tracing and computational steering for interactive blood flow simulation*, Comput Phys Commun 181, 2010

M Ricci, MDM, ... *A molecular level simulation of a twisted nematic cell*, Faraday Discuss 144, 2010

MDM, ... *HemeLB: a high performance parallel lattice-Boltzmann code for large-scale fluid flow in complex geometries*, Comput Phys Commun 178, 2008

28/03/2017

Marco Domenico Mazzeo

Elenco delle pubblicazioni allegate e tesi di dottorato

Luca Panizzi

Tesi di dottorato dal titolo: "*One-Loop Electroweak Analysis for Third Family Scalar Quarks Production at LHC*".

L'elenco completo delle mie pubblicazioni è documentato nel CV. Il seguente elenco delle pubblicazioni il cui testo è allegato alla domanda è in ordine cronologico.

1. G. Cacciapaglia, R. Chierici, A. Deandrea, L. Panizzi, S. Perries, S. Tosi, "Four tops on the real projective plane at LHC," JHEP **1110** (2011) 042, arXiv:1107.4616 [hep-ph]. https://arxiv.org/abs/1107.4616
2. G. Cacciapaglia, A. Deandrea, N. Gaur, D. Harada, Y. Okada and L. Panizzi, "Heavy Vector-like Top Partners at the LHC and flavour constraints," JHEP **1203** (2012) 070, arXiv:1108.6329 [hep-ph]. https://arxiv.org/abs/1108.6239
3. G. Cacciapaglia, A. Deandrea, L. Panizzi, "Superluminal neutrinos in long baseline experiments and SN1987a," JHEP **1111** (2011) 137, arXiv:1109.4980 [hep-ph]. https://arxiv.org/abs/1109.4980
4. Y. Okada and L. Panizzi, "LHC signatures of vector-like quarks," Adv. High Energy Phys. **2013** (2013) 364936, arXiv:1207.5607 [hep-ph]. https://arxiv.org/abs/1207.5607
5. G. Cacciapaglia, A. Deandrea, S. Perries, V. Sordini and L. Panizzi, "Heavy Vector-like quark with charge 5/3 at the LHC," JHEP **1303** (2013) 004, arXiv:1211.4034 [hep-ph]. https://arxiv.org/abs/1211.4034
6. G. Cacciapaglia, A. Deandrea, J. Ellis, J. Marrouche and L. Panizzi, "LHC Missing-Transverse-Energy Constraints on Models with Universal Extra Dimensions," Phys. Rev. D **87** (2013) 075006, arXiv:1302.4750 [hep-ph]. https://arxiv.org/abs/1302.4750
7. M. Buchkremer, G. Cacciapaglia, A. Deandrea and L. Panizzi, "Model Independent Framework for Searches of Top Partners," Nucl. Phys. B **876** (2013) 376, arXiv:1305.4172 [hep-ph]. https://arxiv.org/abs/1305.4172
8. D. Barducci, S. Belyaev, M. Buchkremer, G. Cacciapaglia, A. Deandrea, S. De Curtis, J. Marrouche, S. Moretti and L. Panizzi, "Framework for Model Independent Analyses of Multiple Extra Quark Scenarios," JHEP **1412** (2014) 080, arXiv:1405.0737 [hep-ph]. https://arxiv.org/abs/1405.0737
9. S. F. King, A. Merle and L. Panizzi, "Effective theory of a doubly charged singlet scalar: complementarity of neutrino physics and the LHC," JHEP **1411** (2014) 124, arXiv:1406.4137 [hep-ph]. https://arxiv.org/abs/1406.4137
10. G. Cacciapaglia, A. Deandrea, N. Gaur, D. Harada, Y. Okada and L. Panizzi, "Interplay of vector-like top partner multiplets in a realistic mixing set-up," JHEP **1509** (2015) 012, arXiv:1502.00370 [hep-ph]. https://arxiv.org/abs/1502.00370
11. T. Geib, S. F. King, A. Merle, J. M. No and L. Panizzi, "Probing the Origin of Neutrino Masses and Mixings via Doubly Charged Scalars: Complementarity of the Intensity and the Energy Frontiers," Phys. Rev. D **93** (2016) no.7, 073007 arXiv:1512.04391 [hep-ph]. https://arxiv.org/abs/1512.04391
12. S. Kraml, U. Laa, L. Panizzi and H. Prager, "Scalar versus fermionic top partner interpretations of $t\bar{t} + E_T^{\rm miss}$ searches at the LHC," JHEP **1611** (2016) 107 arXiv:1607.02050 [hep-ph]. https://arxiv.org/abs/1607.02050

Genova, 22/03/2017

24.3.17,

Curriculum Vitae

Christian Gross

Personal Details

Education and Research Experience

since 10.'14	Postdoc *at University of Helsinki* (group O. Lebedev)
10.'11 - 09.'14	Postdoc *at Universität Basel* (group S. Antusch)
11.'09 - 09.'11	Postdoc *at Technische Universität Dortmund* (group G. Hiller)
11.'06 - 07.'09	Ph.D. studies in Physics *at Universität Hamburg* (grade: "very good") supervisors: Laura Covi and Jan Louis
04.'00 - 07.'06	Physics studies *Universität Heidelberg* (grade: "1.0 with distinction") supervisor for diploma thesis: Arthur Hebecker
03.'03 - 12.'03	Physics studies *at University of Adelaide*
06.'98 - 03.'00	Compulsary civilian service and backpacking trip
06.'98	Abitur (secondary school graduation) *at Helmholtz-Gymnasium Bielefeld, Germany*

Seminar Talks and Talks at Conferences/Workshops

02.'17	Tallinn, theory seminar, *talk: "Dark matter from hidden gauge groups"*
09.'16	Hamburg, DESY Theory Workshop 2016, *talk: "Multicomponent WIMP Dark Matter from Gauge Symmetries"*
09.'16	Mainz, MITP program "Effective Field Theories as Discovery Tools", *talk: "Multicomponent Dark Matter from Gauge Symmetry"*
05.'16	Valencia, Planck 2016 conference, *talk: "Drell-Yan Constraints on New Electroweak States and the Di-photon Anomaly"*
04.'16	Hamburg, DESY seminar, *talk: "Gauge fields as dark matter"*
11.'15	Helsinki, department seminar, *talk: "Gauge fields as dark matter"*
10.'15	Albufeira, conference "The Standard Theory and Beyond in the LHC Era", *talk: "Gauge fields as dark matter"*
09.'15	Hamburg, DESY Theory Workshop 2015, *talk: "Gauge fields as dark matter"*
05.'15	Tampere, particle cosmology meeting, *talk: "Gauge fields as dark matter"*
05.'15	Ioannina, Planck 2015 conference, *talk: "A second Higgs from the Higgs portal"*
04.'15	LPT Orsay, Particle Physics Seminar, *talk: "A second Higgs from the Higgs portal"*
12.'14	Helsinki, department seminar, *talk: "SUSY GUT models with non-Abelian flavour symmetry"*
07.'13	Niigata, FLASY13 workshop, *talk: "A flavor GUT model with $\theta_{13}^{\mathrm{PMNS}} = \theta_C/\sqrt{2}$"*
09.'12	Hamburg, DESY Theory Workshop 2012, *talk: "Squark Flavor Implications from $\bar{B} \to \bar{K}^{(*)} l^+ l^-$"*

08.'12	Beijing, SUSY 2012 conference, *talk: "Squark Flavor Implications from* $\bar{B} \to \bar{K}^{(*)} l^+ l^-$*"*
05.'12	Cambridge, HEP phenomenology joint Cavendish-DAMTP seminar, *talk: "Squark Flavor Implications from* $\bar{B} \to \bar{K}^{(*)} l^+ l^-$*"*
09.'11	Fermilab, SUSY 2011 conference, *talk: "Squark flavor constraints from* $\bar{B} \to \bar{K}^{(*)} l^+ l^-$*"*
05.'11	DESY Hamburg, LHC-D SUSY/BSM + Neutrinos and LFV workshop, *talk: "Flavorful hybrid anomaly-gravity mediation"*
04.'11	Mainz, Theory Seminar, *talk: "Flavorful hybrid anomaly-gravity mediation"*
03.'11	MPI für Physik, Munich, Astroparticle Seminar, *talk: "Flavorful hybrid anomaly-gravity mediation"*
12.'10	Rome, Discrete 2010 conference, *talk: "Hybrid anomaly-gravity mediation"*
05.'10	MPI Munich, Theory Seminar, *talk: "de Sitter vacua and inflation in no-scale string models"*
09.'09	TU Dortmund, Theory Seminar, *talk: "de Sitter vacua and inflation in no-scale string models"*
05.'09	Padua, Planck 2009 conference, *talk: "de Sitter vacua in no-scale string models without uplifting"*
03.'09	Hamburg, SFB 676 meeting, *talk: "de Sitter vacua and inflation in supergravity and string theory"*
03.'08	Bad Honnef, "Beyond the Standard Model" workshop, *talk: "de Sitter vacua in no-scale supergravity from string theory"*
05.'06	Heidelberg, "Beyond the Standard Model" seminar, *talk: "Stabilizing supersymmetric orbifold models"*

Teaching Activities

- LECTURES

spring '15	University of Helsinki *Lecture "Physics beyond the Standard Model" (jointly with V. Keus)*

- TUTORIALS

fall '15	University of Helsinki *Tutorial for lecture "Theories in Particle Physics" by O. Lebedev*
fall '13	Universität Basel *Tutorial for lecture "Early Universe Cosmology" by S. Antusch*
spring '13	Universität Basel *Tutorial for lecture "Higher Quantum Mechanics" by S. Antusch*
fall '12	Universität Basel *Tutorial for lecture "Theoretical Elementary Particle Physics" by S. Antusch*
spring '12	Universität Basel *Tutor for undergraduate seminar "The Early Universe" by S. Antusch*
spring '12	Universität Basel *Tutorial for lecture "Higher Quantum Mechanics" by S. Antusch*
summer '11	TU Dortmund *Tutorial for lecture "Higher Quantum Mechanics" by G. Hiller*
summer '10	TU Dortmund *Tutorial for lecture "Quantum Field Theory" by A. Lenz*
winter '05	Universität Heidelberg *Tutorial for lecture "Quantum Mechanics" by O. Nachtmann*
summer '05	Universität Heidelberg *Tutorial for lecture "Theoretical Mechanics" by A. Hebecker*

24.3.17,

Research Visits (at least 1 week)

08.'16	MITP, Mainz
04.'15	LPT, Orsay
12.'14	LPT, Orsay
06.'13	GGI, Florence
07.-09.'11	Boston University
06.'10	CERN, Geneva

Marco Domenico Mazzeo

<u>*Curriculm Vitae*</u>

Personal Data

Education

9/2005 - 5/2009: PhD, University College London (UCL), UK
Thesis: *Lattice-Boltzmann simulations of cerebral blood flow*, web link: eprints.ucl.ac.uk/19357

10/2003: Bachelor degree in Physics at Bologna's University, Italy
Thesis: *Monte Carlo simulations of liquid crystals with particle methods*

Relevant Work Experience

9/2012 - present: *Freelance physicist, researcher, teacher and consultant*, Bologna, Italy
· Collaboration with a company of the Bologna's epicentre for the development of an innovative energy technology
· Independent researcher of alternative physics theories and of new energy technologies
· Co-developer of the software 'ClinicalVolumes' (www.clinicalvolumes.com), supported by King's College London
· Teacher of Physics, Mathematics, Programming and Algorithms

10/2009 - 1/2012: *Fast, accurate fluid simulation and rendering*
Post-Doc at Pompeu Fabra University, Barcelona, Spain

9/2005 - 05/2009: *Cerebral blood flow simulation and visualisation with parallel machines*
PhD & Research assistance, UCL

9/2002 - 07/2005: *Parallel Monte Carlo simulation of liquid crystals with large-scale particle systems*
Research conducted at the Bologna's University (partly covered by two 3-month fellowships respectively started on January 12, 2004, and on May 9, 2005) including a 1-year lab's research needed for the bachelor thesis, and at the Edinburgh Parallel Computing Centre (EPCC) as a 3-month HPC-Europa project visitor (from September 13, 2004)

Projects

euHeart (EU), cvREMOD (Spain), CDTEAM (Spain), TEAM (Philips), VPH-NoE (EU), MSV (International), EPSRC (UK), GENIUS (UK-US), ViroLab (EU), RealityGrid (UK), HPC-EUROPA (EU), FIRB GRID (Italy), DEISA (EU)

Selected Journal Articles with Personal Contributions

<u>MDM</u> *Fast discontinuous-Galerkin lattice-Boltzmann simulations on GPUs via maximal kernel fusion*, Comput Phys Commun 184, 2013
· First GPU implementation of the present method, optimised for speed and precision of calculations
· Found and leveraged potent programming scheme: maximal kernel fusion + heterogeneous fetches mix
· Multi-GigaDOF/s per simulation stage on GeForce GTX 480 in double precision @ spectral accuracy

<u>MDM</u> *The Spy Element Method – A universal approach to complex computing on manycore processors*, J Comput Sci 3, 2012

· New ideas for parallelising/accelerating complex workloads on Manycores wo/ Atomics, sorting and prefix scans

· ~2X speedup w.r.t a version written by me ~30% faster than that of the NVIDIA's CUDA SDK code "Particles"

RS Saksena, <u>MDM</u>, ... *Petascale lattice-Boltzmann studies of amphiphilic cubic liquid crystalline materials in a globally high-performance computing and visualisation environment*, Phil Trans Royal Soc A 368, 2010

Designer and developer of the new in situ parallel global-illumination renderer based on Path Tracing (Sec. 3):

· Domain decomposition + MPI-based inter-processor communications

· Tunable load balancing w/ global-synchronisation enabling scheduler of intra- and cross-domain rays

· Minimally invasive in situ memory solution → High level of productivity and 'unlimited' problem size

<u>MDM</u>, ... *The Linked Neighbour List (LNL) method for fast off-lattice Monte Carlo simulations of fluids*, Comput Phys Commun 181, 2010

· Designer and developer of the new method and of it variants

· Transformed the original insanely memory incoherent algorithm to a cache friendly version

<u>MDM</u>, ... *In situ ray tracing and computational steering for interactive blood flow simulation*, Comput Phys Commun 181, 2010

Designer and developer of the new in situ parallel ray tracer and inter-processor image assembler:

· Optimised object-order ray tracer + OpenMP / MPI + sparse domain decomposition

· Up to many hundreds of simulated and rendered timesteps/s

Co-designer of the lightweight synchronisation-free two-way client-cluster communication scheme

M Ricci, <u>MDM</u>, ... *A molecular level simulation of a twisted nematic cell*, Faraday Discuss 144, 2010

· Full author of the new parallel Monte Carlo code for the simulation of large scale molecular systems

<u>MDM</u>, ... *HemeLB: a high performance parallel lattice-Boltzmann code for large-scale fluid flow in complex geometries*, Comput Phys Commun 178, 2008

Designer and developer of the new fluid solver:

· New domain decomposition + optimised algorithms for intra/inter-processor and inter-machine tasks

· Super/quasi-linear speedup until $O(1000)$ lattice sites per processor core

Other Journal Articles

<u>MDM</u> *A unified physics theory - Part I*, in preparation

<u>MDM</u> *A unified physics theory - Part II*, in preparation

S Cito, <u>MDM</u>, L Badimon, *A review of macroscopic thrombus modeling methods*, Thromb Res 131, 2013

I Larrabide, ..., <u>MDM</u>, ... *AngioLab – a software tool for morphological analysis and endovascular treatment planning of intracranial aneurysms*, Comput Methods Programs Biomed 108, 2012

GM Doctors, <u>MDM</u>, PV Coveney, *A computationally efficient method for simulating fluid flow in elastic pipes in three dimensions*, Comput Phys Commun 181, 2010

RS Saksena, ..., <u>MDM</u>, ... *Real science at the Petascale*, Phil Trans Royal Soc A 367, 2009

SK Sadiq, <u>MDM</u>, ... *Patient-specific simulation as a basis for clinical decision-making*, Phil Trans Royal Soc A 366, 2008

Articles in Proceedings

MC Villa-Uriol, ..., MDM, ... *AngioLab: Integrated technology for patient-specific management of intracranial aneursysms*, EMBS' 10

S Manos, MDM, ... *Distributed MPI cross-site run performance using MPIg*, HPDC' 08

S Manos, S Zasada, MDM, ... *Patient specific whole cerebral blood flow simulation: A future role in neurovascular pathologies*, TG' 08

Competence & Experience

Experimental Physics – Successful experiments carried out to develop electric waves through variants of the conventional methods relying on instabilities and substantial, external brute forces.

Theoretical Physics – Identification of several deficiencies and incongruities of Microsphysics and Astrophysics. Development of a unified physics theory with several new theoretical ingredients

Computational Physics – Experience in dealing with complex fluids, CFD and FSI

Modelling – Experience in implementing: Finite-Difference Method, lattice-Boltzmann methods, discontinuous-Galerkin versions, Monte Carlo Method, Molecular Dynamics and SPH. Knowledge of other tens of simulation models and methods: mesh-based, meshfree and hybrid including Molecular Dynamics, Discrete Simulation Monte Carlo, DPD, Finite Point Method, Vortex Method, Finite-Element/Volume Methods, Finite-Volume Particle Method, spectral and discontinuous Galerkin Methods, Immersed Boundary Methods

Computer Graphics – Experience in implementing parallel Ray Tracing and Path Tracing, in situ parallel visualisation methods, parallel Particle Tracing, Photon Mapping, volume rendering, procedural iso-surfacing, adaptive subdivision of surfaces and tetrahedral meshes, texture mapping, real-time rendering, segmentation techniques, GPU shaders

Programming Languages & APIs – C, C++, Fortran, MPI, MPIg, OpenMP, CUDA, GLSL, OpenGL

Grid Computing – NCSA's GPU cluster, HECToR, HPCx, NGS & LONI nodes, Ranger, BigBen, Abe, Mercury

Referee Service

Computer Physics Communications, Computer Methods in Applied Mechanics and Engineering, Physics of Fluids

28/03/2017

CURRICULUM VITAE

Luca Panizzi

Genova, 22/03/2017

Personal Data

Education and qualifications

September 2005

Degree in Physics, University of Florence, Italy
Thesis Title: *Neutrini a Massa Variabile in Cosmologia e Principio di Equivalenza* (in English: *Mass Varying Neutrinos in Cosmology and the Equivalence Principle*)
Advisors: Prof. Antonio Masiero (University of Padova) and Prof. Roberto Casalbuoni (University of Florence)

March 2009

Ph.D. in Physics, University of Trieste, Italy
Thesis Title: *One-Loop Electroweak Analysis for Third Family Scalar Quarks Production at LHC*
Advisor: Prof. Claudio Verzegnassi (University of Trieste)

January 2014

Qualification aux fonctions de maître de conférences (eligibility to access faculty positions of associate professor in France)

October 2014

Participation to the "Postgraduate Certificate in Academic Practice Session 5: Supervising Research Students" at the University of Southampton

Positions

2009 - 2012	Postdoctoral position (Chercheur CNRS), Institut de Physique Nucléaire de Lyon and CNRS
2012 - 2016	Postdoctoral Research Associate, University of Southampton, UK
2016 - present	Postdoctoral position, University of Genova, Italy

Visiting positions and affiliations

March 2009 - June 2009	Visitor, School of Physics and Astronomy, University of Southampton, UK
July 2009 - November 2009	Visitor, Department of Theoretical Physics, University of Trieste, Italy
November 2010	One-month collaboration visit to KEK, Tsukuba, Japan
February 2011 - March 2011	One-month collaboration visit to Tsinghua University, Beijing, China
October 2012 - present	Visiting Scientist, Rutherford Appleton Laboratory (RAL), UK
July 2015	Two-weeks collaboration visit to FAPESP, Sao Paulo, Brazil
June 2015 - present	Analysis-based affiliation to the CMS collaboration
October 2016 - present	Visiting Scientist, University of Southampton, UK
July 2017 - August 2017	Two-months visiting position, CERN

Grants

March 2009 - June 2009	Royal Society International Travel Grants 2008
July 2009 - November 2009	Grant of the Consorzio per la Fisica, University of Trieste

Teaching, Supervision and Tutorial Experience

Teaching

2012-2013	Demonstrator for the laboratory computing module "PHYS2022, Physics from evidence I", University of Southampton
2014	Demonstrator for the laboratory module "PHYS6008, Physics from Evidence II", University of Southampton
2014	Demonstrator for the module "MATH1007, Mathematical Methods for Physical Sciences", University of Southampton
2017	Demonstrator for the module of General Physics (FIS/01) at the Engineering Department, University of Genova

Supervision

2013	Supervisor of a student of Master M1 of ENS-Lyon for a three-months internship at the University of Southampton
2014-present	Co-supervision of two PhD students in the Southampton High Energy Physics group
2015	Supervision of two students of Master M1 of ENS-Lyon for three-months internships at the University of Southampton
2016	Co-supervision of an undergraduate student of the University of Southampton for his research placement in the Southampton High Energy Physics group

Tutorial at PhD schools

2014	Tutor for the BUSSTEPP 2014 UK PhD School at the University of Southampton
2015	Tutor for the BUSSTEPP 2015 UK PhD School at the King's College, London
2016	Tutor for the BUSSTEPP 2016 UK PhD School at the University of Manchester

Referee Activity

Physical Review D (PRD), Journal of High Energy Physics (JHEP), Physics Letters B (PLB), Physical Review Letters (PRL)

Organisation and administration activity

2010-2012	Member of the équipe séminaires in the IPN Lyon
2013-2014	Organisation of the Thursday (internal) seminars of the Southampton High Energy Physics group
2014	Member of the LOC of the Fourth NExT PhD Workshop at the University of Southampton
2014	Member of the LOC of the BUSSTEPP 2014 UK PhD School at the University of Southampton
2014-2016	Organisation of the Friday (external) seminars of the Southampton High Energy Physics group

Computer Competences

Operative Systems	Linux
Software	Good knowledge of C++, Fortran, Perl, Python, ROOT, Mathematica and of specific particle physics software as Madgraph, CalcHep and Feynrules. I have developed a public software, with name XQCAT (eXtra Quark Combined Analysis Tool).

Languages

Italian	Mother language
English	Very Good in speaking, writing and reading
French	Very Good in speaking, writing and reading

Outreach Activity

2008 - present	activity of science popularization through public conferences organised by the amateur astronomers association in Mantova, Italy, about particle physics and cosmology subjects
2013	Outreach activity at the Winchester Science Centre and Planetarium, UK
2017	Participation to the "Piano Nazionale Lauree Scientifiche" (outreach activity for high school students at the University of Genova, Italy)

Conferences attended

Conferences where I gave (or will be giving) a talk are marked with *

1. *13th International Symposium on Particles, Strings and Cosmology: PASCOS-07*, Imperial College, London, 2-7 July 2007
2. *V workshop italiano sulla fisica p-p ad LHC*, Perugia, 30 January - 2 February 2008
3. **Rencontres de Physique des Particules 2010*, IPN Lyon, 25-27 January 2010
4. *GDR Terascale*, Saclay, 29-31 March 2010
5. *Planck 2010*, CERN, 31 May - 4 June 2010
6. *TOOLS 2010 - Tools for SUSY and the New Physics, Sharpening our Tools*, Winchester, 29 June - 2 July 2010
7. **Rencontres de Physique des Particules 2011*, LPC Clermont-Ferrand, 13-14 January 2011
8. *Implications of LHC results for TeV-scale physics*, CERN, 29 August - 2 September 2011
9. **Frontiers in Neutrino Physics*, APC, Paris, October 4-6, 2011
10. **GDR Terascale*, CPPM Marseille, 11-13 October 2011
11. **Focus Workshop on Heavy Quarks at LHC*, National Taiwan University, 19-20 January 2012
12. *TOP 2012 - 5th International Workshop on Top Quark Physics*, Winchester, 16-21 September 2012
13. *Neutrinos at the forefront of elementary particle physics and astrophysics*, Lyon, 22-24 October 2012
14. **NExT Meeting*, Royal Holloway University of London, 14 November 2012

15. **Rencontres de Physique des Particules 2013*, LPSC Grenoble, 16-18 January 2013
16. **LC13: Exploring QCD from the infrared regime to heavy flavour scales at B-factories, the LHC and a Linear Collider*, ECT Trento, 16-20 September 2013
17. **New Perspectives in Dark matter*, IPN Lyon, 22-25 October 2013
18. **19th International Symposium on Particles, Strings and Cosmology: PASCOS 2013*, Taipei, 20-26 November 2013
19. *Annual Theory Meeting 2013*, Durham University, 16-18 December 2013
20. **Rencontres de Physique des Particules 2014*, IPHC Strasbourg, 20-22 January 2014
21. **Excited QCD 2014*, Sarajevo, 2-8 February 2014
22. **Astroparticle Physics 2014*, Amsterdam, 23-28 June 2014
23. **26th Recontres de Blois - Particle Physics and Cosmology*, Blois, 18-23 May 2014
24. **Workshop on vector-like quarks 2014*, DESY, Hamburg, 15-16 September 2014
25. **Calculations for Modern and Future Colliders*, Joint Institute for Nuclear Research, Dubna, 23-30 July 2015
26. **NExT Meeting*, Rutherford Appleton Laboratory, Didcot, 4 November 2015
27. **IFAE 2016*, University of Genova, 30 March - 1 April 2016
28. **Special CMS B2G Event at the LPC*, Fermilab, Chicago, 7-8 April 2016
29. **(Re)interpreting the results of new physics searches at the LHC*, CERN, 15-17 June 2016
30. **LIO international conference on Composite Models, Electroweak Physics and the LHC*, Lyon, France, 5-8 September 2016
31. *(Re)interpreting the results of new physics searches at the LHC*, CERN, 12-14 December 2016

PhD Schools attended

1. *Summer School on Particle Physics*, ICTP, Trieste, 11-22 June 2007
2. *The 2008 Hadron Collider Physics Summer School*, Fermilab, Chicago, 12-22 August 2008
3. *The 4th UniverseNet School - Frontiers of Particle Cosmology*, Lecce, 13-19 September 2010

Publications, Preprints and Proceedings

Publications

1. M. Beccaria, G. Macorini, L. Panizzi, F. M. Renard and C. Verzegnassi, "Supersymmetry spectroscopy in stop-chargino production at LHC", Phys. Rev. **D74** (2006) 093009, [arXiv: hep-ph/0610075].
2. F. del Aguila et al., "Collider aspects of flavour physics at high Q," Eur. Phys. J. **C57** (2008) 183-308, arXiv:0801.1800 [hep-ph].
3. M. Beccaria, G. Macorini, L. Panizzi, F. M. Renard and C. Verzegnassi, "Stop-antistop and sbottom-antisbottom production at LHC: a one-loop search for model parameters dependence," Int. J. Mod. Phys. **A23** (2008) 4779-4810, arXiv:0804.1252 [hep-ph].
4. M. Beccaria, G. Macorini, E. Mirabella, L. Panizzi, F. M. Renard and C. Verzegnassi, "One-loop electroweak effects on stop-chargino production at LHC," Int. J. Mod. Phys. **A24** (2009) 5539, arXiv:0812.4375 [hep-ph].
5. M. Beccaria, G. Macorini, L. Panizzi, F. M. Renard and C. Verzegnassi, "Associated production of charged Higgs and top at LHC: the role of the complete electroweak supersymmetric contribution," Phys. Rev. **D80** (2009) 053011, arXiv:0908.1332 [hep-ph].
6. M. Beccaria, G.O. Dovier, G. Macorini, E.Mirabella, L. Panizzi, F. M. Renard and C. Verzegnassi, "Semi-inclusive bottom-Higgs production at LHC: The complete one-loop electroweak effect in the MSSM," Phys. Rev. **D82** (2010) 093018, arXiv:1005.0759 [hep-ph].

7. G. Macorini, S. Moretti, L. Panizzi, "Strong and Electro-Weak Supersymmetric Corrections to Single Top Processes at the Large Hadron Collider," Phys. Rev. **D82** (2010) 054016, arXiv:1006.1501 [hep-ph].
8. G. Cacciapaglia, R. Chierici, A. Deandrea, L. Panizzi, S. Perries, S. Tosi, "Four tops on the real projective plane at LHC," JHEP **1110** (2011) 042, arXiv:1107.4616 [hep-ph].
9. G. Cacciapaglia, A. Deandrea, N. Gaur, D. Harada, Y. Okada and L. Panizzi, "Heavy Vector-like Top Partners at the LHC and flavour constraints," JHEP **1203** (2012) 070, arXiv:1108.6329 [hep-ph].
10. G. Cacciapaglia, A. Deandrea, L. Panizzi, "Superluminal neutrinos in long baseline experiments and SN1987a," JHEP **1111** (2011) 137, arXiv:1109.4980 [hep-ph].
11. Y. Okada and L. Panizzi, "LHC signatures of vector-like quarks," Adv. High Energy Phys. **2013** (2013) 364936, arXiv:1207.5607 [hep-ph].
12. G. Cacciapaglia, A. Deandrea, S. Perries, V. Sordini and L. Panizzi, "Heavy Vector-like quark with charge 5/3 at the LHC," JHEP **1303** (2013) 004, arXiv:1211.4034 [hep-ph].
13. G. Cacciapaglia, A. Deandrea, J. Ellis, J. Marrouche and L. Panizzi, "LHC Missing-Transverse-Energy Constraints on Models with Universal Extra Dimensions," Phys. Rev. D **87** (2013) 075006, arXiv:1302.4750 [hep-ph].
14. M. Buchkremer, G. Cacciapaglia, A. Deandrea and L. Panizzi, "Model Independent Framework for Searches of Top Partners," Nucl. Phys. B **876** (2013) 376, arXiv:1305.4172 [hep-ph].
15. D. Barducci, S. Belyaev, J. Blamey, S. Moretti, L. Panizzi and H. Prager, "Towards a model-independent approach to the analysis of interference effects in pair production of new heavy quarks," JHEP **1407** (2014) 142, arXiv:1311.3977 [hep-ph].
16. N. Chen, Y. Zhang, Q. Wang, G. Cacciapaglia, A. Deandrea and L. Panizzi, "Higgsphobic and fermiophobic Z' as a single dark matter candidate," JHEP **1405** (2014) 088, arXiv:1403.2918 [hep-ph].
17. D. Barducci, S. Belyaev, M. Buchkremer, G. Cacciapaglia, A. Deandrea, S. De Curtis, J. Marrouche, S. Moretti and L. Panizzi, "Framework for Model Independent Analyses of Multiple Extra Quark Scenarios," JHEP **1412** (2014) 080, arXiv:1405.0737 [hep-ph].
18. S. F. King, A. Merle and L. Panizzi, "Effective theory of a doubly charged singlet scalar: complementarity of neutrino physics and the LHC," JHEP **1411** (2014) 124, arXiv:1406.4137 [hep-ph].
19. D. Barducci, A. Belyaev, M. Buchkremer, J. Marrouche, S. Moretti and L. Panizzi, "XQCAT: eXtra Quark Combined Analysis Tool,", Comput. Phys. Commun. **197** (2015) 263, arXiv:1409.3116 [hep-ph].
20. G. Cacciapaglia, A. Deandrea, N. Gaur, D. Harada, Y. Okada and L. Panizzi, "Interplay of vector-like top partner multiplets in a realistic mixing set-up," JHEP **1509** (2015) 012, arXiv:1502.00370 [hep-ph].
21. T. Geib, S. F. King, A. Merle, J. M. No and L. Panizzi, "Probing the Origin of Neutrino Masses and Mixings via Doubly Charged Scalars: Complementarity of the Intensity and the Energy Frontiers," Phys. Rev. D **93** (2016) no.7, 073007, arXiv:1512.04391 [hep-ph].
22. S. Jain, F. Margaroli, S. Moretti and L. Panizzi, "The 750 GeV threshold to a new particle world," arXiv:1605.08741 [hep-ph], accepted for publication in PRD.
23. S. Kraml, U. Laa, L. Panizzi and H. Prager, "Scalar versus fermionic top partner interpretations of $t\bar{t} + E_T^{miss}$ searches at the LHC," JHEP **1611** (2016) 107, arXiv:1607.02050 [hep-ph].

Preprints

1. S. Moretti, D. O'Brien, L. Panizzi and H. Prager, "Production of extra quarks at the Large Hadron Collider beyond the Narrow Width Approximation," arXiv:1603.09237 [hep-ph].
2. A. Belyaev, L. Panizzi, A. Pukhov and M. Thomas "Dark Matter characterization at the LHC in the Effective Field Theory approach," arXiv:1610.07545 [hep-ph].

Proceedings

1. G. Brooijmans, R. Contino, B. Fuks, F. Moortgat, P. Richardson, S. Sekmen, A. Weiler and A. Alloul *et al.*, "Les Houches 2013: Physics at TeV Colliders: New Physics Working Group Report," arXiv:1405.1617 [hep-ph].

2. L. Panizzi, "Vector-like quarks: t' and partners," Nuovo Cim. C **037** (2014) 02, 69.
3. L. Panizzi "Model-independent Analysis of Scenarios with Vector-like Quarks," Acta Phys. Polon. Supp. **7** (2014) 3, 631.

Research Statement

Luca Panizzi

Characterisation and recasting of signatures of new physics at the LHC

In brief

My research proposal sits in the broad context of the **phenomenology of new physics at the LHC**. After the discovery of the Higgs boson, the focus has now shifted in trying to solve the outstanding issues of the Standard Model (SM), which will eventually – and hopefully – lead to the discovery of signatures of new physics (NP) in the forthcoming years.

I have being working on the phenomenological aspects of various NP scenarios throughout my research career and I have developed a wide range of skills and competences in both theoretical and experimental aspects, which I can now exploit to develop and lead research programmes for the analysis of LHC data in the context of the quest for physics beyond the SM. Indeed, the LHC Run II is ongoing and new data are currently and rapidly piling up and are already being analysed. Therefore it is paramount to develop analysis techniques which can be used to interpret such experimental data and test specific models or try to identify and characterise signals of NP in a model-independent way. My approach to the analysis is mainly bottom-up, and it is nowadays widely adopted by the phenomenological community: it consists in trying to identify relevant signatures in the context of simplified models or effective field theory approaches and reinterpret them to reconstruct more complex scenarios, which can approximate with reasonable accuracy the complete signatures predicted by theoretically motivated models of new physics.

At the moment, my main research activity consists in the analysis of signatures with missing transverse energy (MET), which can be interpreted as originating from dark matter (DM) candidates, with the purpose of **characterising the properties of DM** and especially its **spin**. The strategy is to identify observables or combinations of observables and to develop different analysis techniques (depending on the channel with MET) with the aim of distinguishing different new physics scenarios, characterised by DM candidates with different spin. The importance of this analysis is due to the fact that if signals compatible with the presence of a DM candidate are observed at the LHC, a characterisation of their properties (such as shapes of distributions or correlation between different observables) would allow to embed the DM state in a subset of theoretical scenarios and exclude other scenarios (an example is provided below). This analysis can – and should – be done **before** any possible observation of MET at the LHC. Even if studying how to characterise a still unseen signal seems a risk in terms of the potential impact of this research field, I believe that for the specific case of DM it is a risk worth taking. We have evidence of DM from different indirect observation and this is one of the few evidences of the existence new physics we have: therefore I think that focusing on the analysis and characterisation of potential DM signatures would be crucial in the forthcoming future.

In recent years I have also focused my attention on analysis of signatures generated by the production and decay of **new heavy quarks**, mostly with vector-like properties. As a result of my studies I developed a tool to recast LHC public data (more details will be provided below). In propose to extend and upgrade such techniques to enlarge their range of applicability, also including extra-leptons, and to be able to characterise the properties of extra-fermions (charge, couplings, group representation) in case a signature of new physics compatible with their presence is observed at the LHC. The same techniques can be applied to test models which predict different new particles, such as new charged or doubly charged scalars.

A key point of both parts of the my project will be the **collaboration with experimental groups**, which will result in the contribution to experimental searches and in the design of new analyses for the interpretation of current data in terms of theoretical models of new physics. I am already collaborating with two experimental groups, mostly for the analysis of signatures with missing transverse energy: the CMS groups of São Paulo (Brasil) and RAL (UK), also through an affiliation to the latter group. With the RAL group I am also performing an analysis of final states characterised by two muons and jets (PAS CMS HIG-15-009). In this respect I am one of the few theoretical physicists of my generations who undertakes analyses also working on real data and in close collaboration with the experimental community, thus placing me in the ideal position between theory and experiment for the interpretation of data from the LHC.

In the following sections I will provide a more detailed description of the main branches of my research proposal.

1 Characterisation of the spin of Dark Matter candidates

One of the current "hot topics" among experimental searches and phenomenological analyses at the LHC is the exploration of dark matter (DM) signatures. The number of possible channels where DM signals can be found is large, and a vast literature has been produced about how to identify DM at the LHC. DM signatures are also interesting from a theoretical point of view as a large number of models have been built to extend the SM with DM candidates.

One of the aspect which will become extremely relevant in case a signal compatible with DM is observed is how to determine its properties, and I am currently focusing in particular on its *spin*. The spin plays a crucial role in the interpretation of a DM signal in terms of a theoretical model: a determination of the DM spin at the LHC (or at least the identification of its spin-statistics properties) would rule out or put into tension with data entire classes of models and would allow experiments and phenomenological analyses (both at collider and in complementary sectors, as direct and indirect detection) to focus only on a much smaller subset of signatures which could possibly narrow down the number of viable models to a handful. As an example, a broad class of SUSY scenarios predict fermionic DM (the neutralino), while extra-dimensional scenarios predict a scalar or vectorial DM (usually the KK partner of the photon); therefore the determination of the DM bosonic or fermionic nature would put one of the two classes of models into strong tension with data. The determination of the DM spin, however strongly depends on the assumptions about how the DM interacts with the SM sector. Therefore it will be crucial to identify how different channels are sensitive to the DM spin when different hypotheses about the DM properties are taken into account. This kind of analysis has already been started and I am currently collaborating with two CMS groups for the exploration of mono-jet (with the São Paulo CMS group) and mono-Z signatures (with the RAL CMS group, in which I have been affiliated for this specific analysis) in the context of a two-Higgs-doublet model and of a simplified model respectively[1]. These are only the first preliminary steps of a much broader project: by considering simplified models and minimal consistent scenarios, I will perform a systematic exploration of DM spin hypotheses, taking into account the spin of the mediator as well. The study aims at optimising the analyses of experimental data in order to disentangle the different DM spin hypotheses. The roadmap of this part of the project is the following:

- Identify which channels or combination of channels are more sensitive to different spin hypotheses and optimise the analysis strategies to increase the significance of the signal depending on the spin. In this respect, a first exploration for a final state with top quarks and missing transverse energy which could be generated both by scalar or fermionic top-partner mediators has been recently performed [1], as well as an analysis of monojet final states in the effective field theory approach [2].
- For each specific chanel, identify kinematic variables (or correlations between variables) which could allow to distinguish the signal coming from DM candidates with different spins. Analysis of the shapes of key distributions, and determination of the likelihood ratios of different spin hypothesis to fit the shapes of the distributions. The analysis will also produce projections for future observability of signatures which are currently not sensitive enough.

In case a signal compatible with DM is discovered at the LHC, the focus of this part of the program will be shifted to test in priority the hypotheses compatible with the discovered signal.

Contingency plans. This analysis assumes that a signal compatible with DM will be observed, which seems a risk in terms of long term strategies. However, the results I will obtain will also be used to to recast the experimental data in the same fashion as in the previous section of the project and build a framework to produce exclusion bounds for models of NP which predict a DM candidate. Therefore, even if a DM signal will not be observed in the following years, it will still be possible to effectively contribute in the development of reasting tools which will be essential to test new physics scenarios against experimental data. Furthermore, especially for scenarios with leptophilic DM, the analysis will also be done for lepton colliders, providing predictions for channels for which a future linear collider would be more sensitive.

[1] Simplified models for DM consist in minimal extensions of the SM with a DM state and, possibly, with a further new particle which acts as a mediator of the interactions between the DM and the SM states.

2 Model-independent analysis of scenarios with extra-fermions

Part of my recent works have focused on signatures generated by new heavy extra quarks (XQs), which are predicted by a large number of theoretical models, such as composite Higgs, Little Higgs, or extra-dimensions. On the experimental side, signatures from XQs are among the mostly explored scenarios of exotic NP at the LHC: the discovery of a Higgs boson with mass of 125 GeV has almost completely ruled out the existence of a chiral fourth generation of quarks, but the existence of quarks with vector-like properties is still far from being excluded, though lower bounds on their masses are increasing as data is growing. Experimental searches are indeed gradually strengthening the bounds on their masses considering different hypotheses about their interactions with the SM states. Usually, however, the experimental searches adopt a simplified approach, assuming the existence of only one vector-like quark besides the SM particles, which can only mix with one generation of SM quarks, either one of the two light generations or the third generation. The reinterpretation of data to test theoretically justified scenarios which predict a new *quark sector*, which in general may interact with *all* generations of quarks is therefore challenging. Any final state considered in experimental searches may be obtained starting from more than one new quark, and since in general they have different masses, the kinematic distributions of the particles in the final states may not be trivially reconstructed. Moreover, new XQs may decay into dark matter states, thus producing signatures characterised by missing transverse energy, which are completely different from those commonly investigated in direct searches of XQs.

To address this problem, I and my group of collaborators have designed a new framework to study the signals of scenarios with the presence of multiple XQs in a model-independent way. This project has resulted in the development of a public software called XQCAT [3, 4, 5] (eXtra Quark Combined Analysis Tool). XQCAT allows the users to test scenarios characterised by any number of heavy quarks with general mixing with the SM quarks. The software tests XQ signals against data from experimental searches, considered individually or in statistical combination, and quickly provides robust and conservative exclusion limits for the input scenarios. The key feature of the software is the presence of a database of pre-simulated efficiencies for processes of QCD pair production of XQs, obtained by considering all possible decay channels of the XQ individually. The software then recombines them according to the input benchmark through simple algebraic relations and performs a statistical analysis of the output to provide the exclusion confidence level of the tested scenario. The code has been used to produce our first results and it has started to be acknowledged by the community already in its initial versions.

However, even if recasting current data is crucial from a theoretical point of view, it would be paramount to develop strategies to characterise a signal of new physics compatible with the presence of new extra-quarks, or even new extra-leptons, if this is observed at the LHC. This part of my research project has therefore multiple aims, which are meant to strengthen the recasting potential of the XQCAT code, and to go beyond it:

- inclusion of data from a larger set of experimental searches in the database. This part will be undertaken as long as new searches become available and involves a careful process of validation for each search implemented in our software. This part of the project requires some man-power, and it would be a very effective field for training students interested in LHC phenomenology, as it requires to simulate and analyse BSM signals and to understand all aspects from the MonteCarlo generation to the detector analysis.

- inclusion of signatures coming from a more complete set of NP scenarios, such as XQs decaying into dark matter. This analysis depends on a larger number of variables with respect to scenarios where XQs decay into pure SM states: the couplings between XQ and dark matter and the mass of XQ and dark matter are input variables, and therefore the database of efficiencies will be larger than in the visible decay case. Moreover, if the mass splitting between the XQ and DM is small, the XQ can only undergo three-body decays, making the simulation of the process more complex. The experimental community has shown interest in this aspect, as it is crucial to understand to which extent it is possible to reinterpret SUSY searches in terms of constraints for models where the DM is produced by the decay of heavy quarks. Studies are already in progress, but a systematic exploration has to be performed.

- inclusion of different or more complex production and decay channels, such as EW single production or chain decays. The model-independent parametrisation of these channels involves more parameters (and therefore more computational power) than in the case of QCD pair production. A public model with such implementation has been developed (see Ref.[6]) and is currently widely adopted also by the experimental community. This part of the project is crucial to understand the relevance of signals of single production of XQs, since as the mass bounds increase, single production becomes more and more dominant with respect to pair production, and a correct determination of the peculiar kinematical aspects of single and pair production will be extremely important for the interpretation of signals.

- systematic exploration of subleading contribution and different assumptions, such as large-width, interference effects (in the signal and between signal and background) and loop corrections. This part is the toughest, as these effects are strongly model dependent, and it is not clear if it is possible to find common patterns which can be factorised to provide robust corrections to the leading order approximations. Preliminary results look promising though [7, 8], and further investigations of these aspects will definitely lead to results which will be extremely useful both by the phenomenological and experimental communities.

It is important to stress that most of the previously described analysis involve a detailed knowledge of the kinematics of the signal and therefore, this analysis will also be used to identify observables to characterise the properties of the XQs, such as charge, couplings or representations under $SU(2)$. This would become crucial if a signal compatible with the presence of XQs is observed at the LHC because the characterisation of the properties of new particles would allow to embed them into some scenarios of new physics and possibly exclude others. Analogous techniques can be used for the analysis and characterisation of signals originated by the presence of extra-leptons, which, analogously to extra-quarks, can decay in both SM particles or also DM states.

Moreover, I am planning to apply the same analysis techniques to analyse final states originated by other exotic particles such as charged or doubly charged scalars, heavy vectors or leptoquarks. Early studies have already been performed (see Refs.[9, 10]). The ultimate goal of this part of my project is indeed to provide the community with a comprehensive analysis framework which allows a fast but robust exploration of the parameter space of complex models without the need of performing dedicated and time consuming simulations. The possibility of removing in a conservative way the excluded regions of parameter space of a model with a quick scan through the codes I am developing will greatly simplify and fasten new phenomenological analyses. The final tool will be able to identify the most relevant sectors of a specific model and compute the bounds on its parameter space by considering only the subset of particles which provide the stronger constraints.

Contingency plans. One final aspect that I ought to discuss is about the flexibility of my analysis strategies with respect to dynamically and rapidly changing scenarios, driven by the new data produced at the LHC. It is clear that the discovery of a signal of new XQs would shift the attention of the community from the determination of exclusion limits to the exploration of model candidates. In this case a quick response and adaptation to the changed scenario will be crucial. On one hand, the diversification of the analysis I am proposing, by exploring final states generated by different new particles, guarantees the possibility to place bounds on new physics which predicts signatures different from the observed ones. On the other hand, my research program will also provide precious hints about scenarios which have not been explored yet and which will eventually lead to the observation of a signal. In this respect, the comprehensive analyses of different and subtle phenomenological aspects of the final states generated by new particles will be extremely important for inspiring the design of new search analyses to explore in a deeper way the observed signals.

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