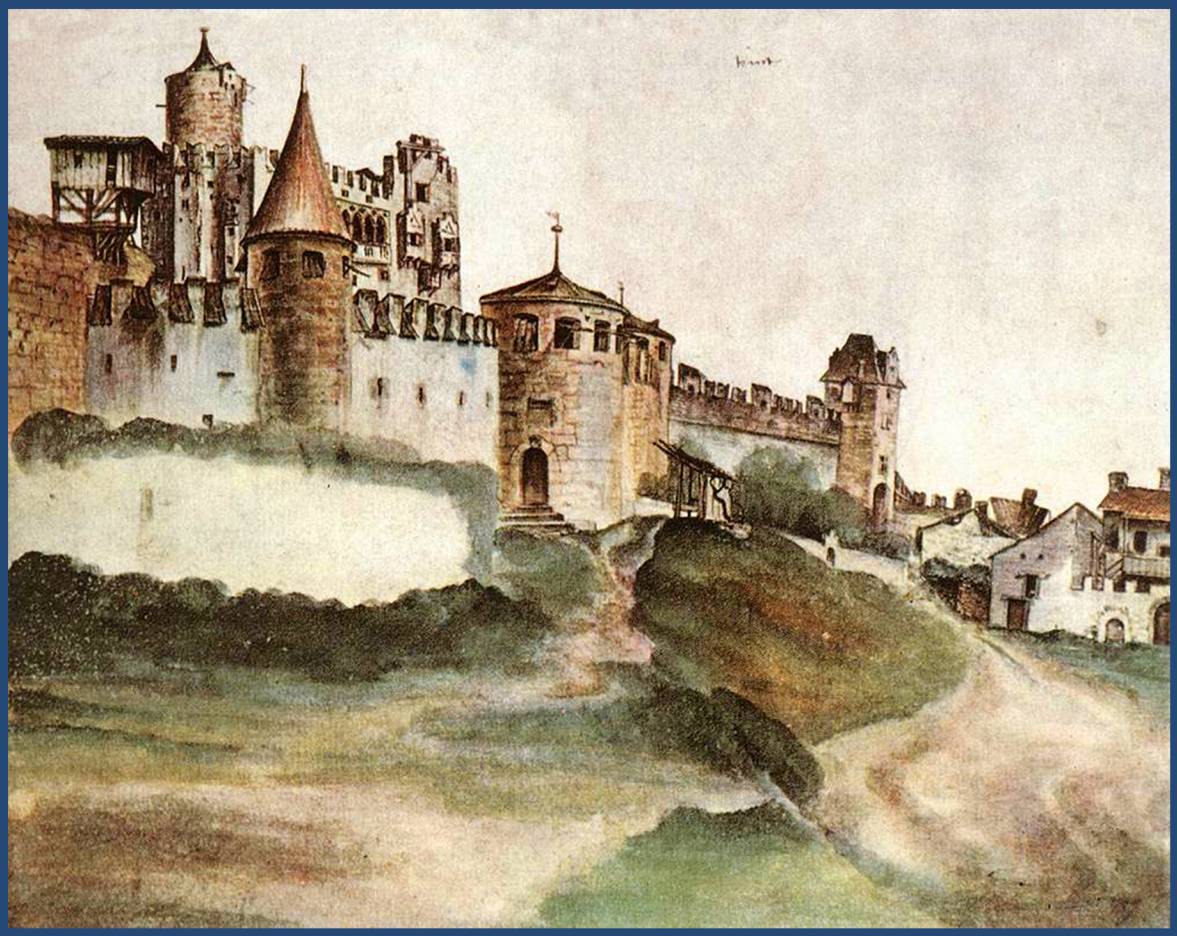
INFN ISTITUTO NAZIONALE DI FISICA NUCLEARE
Laboratori Nazionali di Frascati

FRASCATI PHYSICS SERIES



LFC17: Old and New Strong Interactions from LHC to Future Colliders

ECT*, Trento, Italy, September 11 - 15, 2017

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FRASCATI PHYSICS SERIES

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Volume LXV

Istituto Nazionale di Fisica Nucleare – Laboratori Nazionali di Frascati
Divisione Ricerca
Ufficio Biblioteca e Pubblicazioni
P.O. Box 13, I-00044 Frascati Roma Italy
email: library@lists.lnf.infn.it

ISBN 978-88-86409-88-9-61-2

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Frascati Physics Series Vol. 65 (2017)
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11 - 15 September, 2017

PREFACE

The workshop 'LFC17: Old and New Strong Interactions from LHC to Future Colliders' was held at the European Center for Theoretical Physics (ECT*), Villazzano (TN), Italy, on September 11-15, 2017. It has been the eighth edition of a series which in the beginning was mostly devoted to the physics of high-energy electron-positron Linear Colliders, while it has now become a regular appointment to discuss all projects for future accelerators, both linear and circular, as well as lepton and hadron colliders. Such meetings have been taking place in Italy, gathering both Italian and international scientists active in experiments, theory and phenomenology of future colliders. The location has been ECT* in 2011, 2013 and 2015, whereas the previous editions were held in Florence (2007), Perugia (2009) and Frascati National Laboratories (2008 and 2010).

As for the structure of the workshop, the first day has always been devoted to general presentations on the phenomenology and the experiments at present and future colliders, while the following days we had topical sessions and specific talks on perturbative and non-perturbative Quantum Chromody-namics, heavy ions, leptonic gyromagnetic moment, top-quark physics, electroweak interactions, Higgs phenomenology, physics beyond the Standard Model (BSM) and Dark Matter (DM).

The 2017 edition was focused on the role played by strong interactions, in perturbative and non-perturbative regimes, both within and beyond the SM. The introductive session dealt with general issues on strong interactions at present and future colliders. In particular, the main experimental projects at the future energy frontier, from both viewpoints of physics and accelerators, were reviewed. Moreover, we had an overview of LHC QCD results, discussing the experimental and theoretical perspectives, and of heavy-ion phenomenology at LHC, RHIC and future colliders. The prospects for strongly-interacting physics at future accelerators were presented as well; furthermore, regarding BSM physics, we focused on models based on strong dynamics and their predictions for the LHC and for experiments at higher energy and luminosity, in both pp and e^+e^- regimes.

The main results presented in the perturbative QCD session concerned recent experimental measurements and novel theoretical developments in hard QCD processes. Results on high-p_T reactions at the Large Hadron Collider were highlighted, showing, in particular, recent measurements on vector-boson production in association with QCD jets, diboson, single and double Higgs-boson production. It was pre-

sented an algorithm to calculate jet cross sections up to next-to-next-to-leading order (NNLO) QCD in lepton and hadron collisions, along with new quantitative results based on the CoLorFulNNLO subtraction method. A novel technique for higher-order calculations was discussed: such a method is based on the duality relation between loops and phase-space integrals and an explicit calculation of the total Higgs boson decay rate at NLO was presented. New results on azimuthal correlations among particles in hard QCD scattering were shown, underlying that fixed-order computations can lead to divergences which can be removed by means of a proper all-order resummation procedure. An infrared QCD model, describing the energy dependence of the total cross section at very high energies and the non-diffractive soft and semi-hard collisions in hadronic processes, was also debated.

The 'Non Perturbative QCD and Heavy Ions' session was introduced by a general talk, giving a broad overview of the main items touched more deeply in the specific contributions. A talk was devoted to nuclear parton distribution functions (nPDF's), showing how a wide set of observables in eA, νA and pA collisions can be accommodated within a picture based on collinear factorization. Initial-state effects were also addressed, paying special attention to gluon saturation. The picture, initially developed to describe the low-x evolution of the gluon density and to provide an interpretation of peculiar features of HERA DIS data, was later employed to get a first-principle description of the initial state in high-energy pA and AA collisions. Relativistic hydrodynamics was addressed as well: the major surprise in the field came from the recent discovery of collective effects, suggesting a hydrodynamic interpretation in small systems, like the ones produced in high-multiplicity pp and pA collisions. It was also conveyed the message that the same physics is at work in producing the quenching of jets in AA collisions and in making the initial system thermalize. One of the most important issues to understand in the forthcoming heavy-ion runs of the LHC is the absence of jet-quenching in small systems (pA collisions), which, on the other hand, display signatures of collective flow. Finally, heavy-flavour observables were debated too, given the fact that one has the potential to get access, in particular through bottom-quark measurements, to the transport coefficients of the plasma.

The 'Top Quark Physics' session began with an overview of top-quark phenomenology at the LHC and was concluded by a companion presentation debating the perpectives at future lepton and hadron colliders. Furthermore, recent progress in the POWHEG program for top physics was explored: the latest version of this NLO Monte Carlo generator contains NLO corrections to top decays, width effects, interference between production and decay phases, as well as non-resonant contributions. The top-quark mass extraction was also investigated, taking particular care about the relation between the reconstructed mass and the pole mass; recent NNLO computations of the total $t\bar{t}$ cross section were presented, paying attention to the comparison of analytical and numerical approaches.

The 'Higgs and BSM' session aimed at investigating the role played by strong interactions in physics at the TeV scale and above. The main topics covered were the following: strongly-interacting theories of the Higgs boson and their short-distance realization; strongly-interacting DM; signals at colliders from composite states, emerging as bound states of the new-physics strong interactions; relations between strongly-coupled theories of electroweak symmetry breaking, their apparent fine tuning in parameter space and symmetry-breaking patterns observed in real-world condensed matter systems.

The anomalous magnetic moment of the muon, namely $a_\mu = (g_\mu - 2)/2$ is one of the best known quantities in particle physics, from both experimental and theoretical sides: intriguingly, there is a long-standing discrepancy between the current experimental measurements and the best theoretical predictions within the SM, of the order of $3 - 4$ standard deviations. In the '$g - 2$' session we had an overview of the experimental techniques and results from past experiments, as well as updates on the status of the

future Fermilab (USA) and J-PARC (KEK, Japan) facilities. The theory status of the a_μ calculation was briefly summarized, focusing on a new proposed experiment to measure the hadronic contribution to the running of the electromagnetic coupling constant in the space-like region, via the scattering process $\mu e \to \mu e$. This high-precision measurement will allow to estimate the leading-order hadronic contribution to a_μ, which currently yields the largest theoretical error. An improved analysis of the available data was then presented: the current theoretical error on a_μ may be reduced by 30% and thus induce a discrepancy of 3.9σ between the SM prediction and the current experimental value.

The 'Exotics and Dark Matter' session was opened by a presentation on exotic quarks of charge 5/3, predicted in composite models with higher-isospin multiplets: recasting the present experimental analyses, it is possible to set exclusion bounds on the exotic-quark masses. Moreover, we investigated DM searches at the LHC, with most of the attention devoted to weakly-interacting models, since they are within the experimental reach. In particular, we emphasized the importance of the so-called 'Simplified Models' that are characterized only by the presence of a DM candidate and a mediator with the SM sector. Searches for vector-like top-quark partners at the LHC were motivated and explored: direct searches and indirect constraints from electroweak precision data can play a complementary role in probing the existence of new vector-like quarks. From the experimental viewpoint, we had a summary of the present status of vector-like top-partner searches at the LHC and a presentation discussing the relation between B-decay anomalies and DM in strong-dynamics scenarios. In fact, the recent B-decay anomalies observed by LHCb could be explained in the context of a simple model with strong dynamics, containing a vector-like quark partner, a right-handed neutrino partner and an inert Higgs doublet. As for DM searches at the LHC, we focused on a class of theories in which the DM candidate is a pseudo Nambu–Goldstone boson arising from a strongly-interacting sector: in these models, the experimental results can be re-interpreted in terms of effective field theory approaches.

Most of the oral contributions at the LFC17 workshop are summarized in these proceedings, which are therefore a useful collection, reviewing the state of the art of particle physics in the era of the LHC Run II as well as a number of astrophysics observations, and exploring the prospects for future hadron and lepton colliders. More details and the slides of the talks can be found at:
`http://www.ectstar.eu/node/2228`;
`https://agenda.infn.it/conferenceDisplay.py?confId=13162`.

Before concluding, we wish to warmly thank the conveners, whose names are listed below, for their remarkable effort to invite the speakers and chair the sessions, in such a way to achieve a fruitful workshop and release the present volume. We also acknowledge the INFN 'Commissione IV' and the ECT* for financial support; we are especially grateful to Christian Fossi for his invaluable help with the organization of the logistics.

Conveners:

Andrea Beraudo, INFN Turin (Non Perturbative QCD and Heavy Ions)
Carlo Carloni Calame, INFN Pavia ($g-2$)
Aldo Deandrea, IPN Lyon (Higgs Physics)
Giancarlo Ferrera, University of Milan (Perturbative QCD)
Roberto Franceschini, University of Rome 3 (Beyond the Standard Model)
Orlando Panella, INFN Perugia (Exotics)
Francesco Tramontano, University of Naples (Top Quark Physics)
Alfredo Urbano, CERN (Dark Matter)