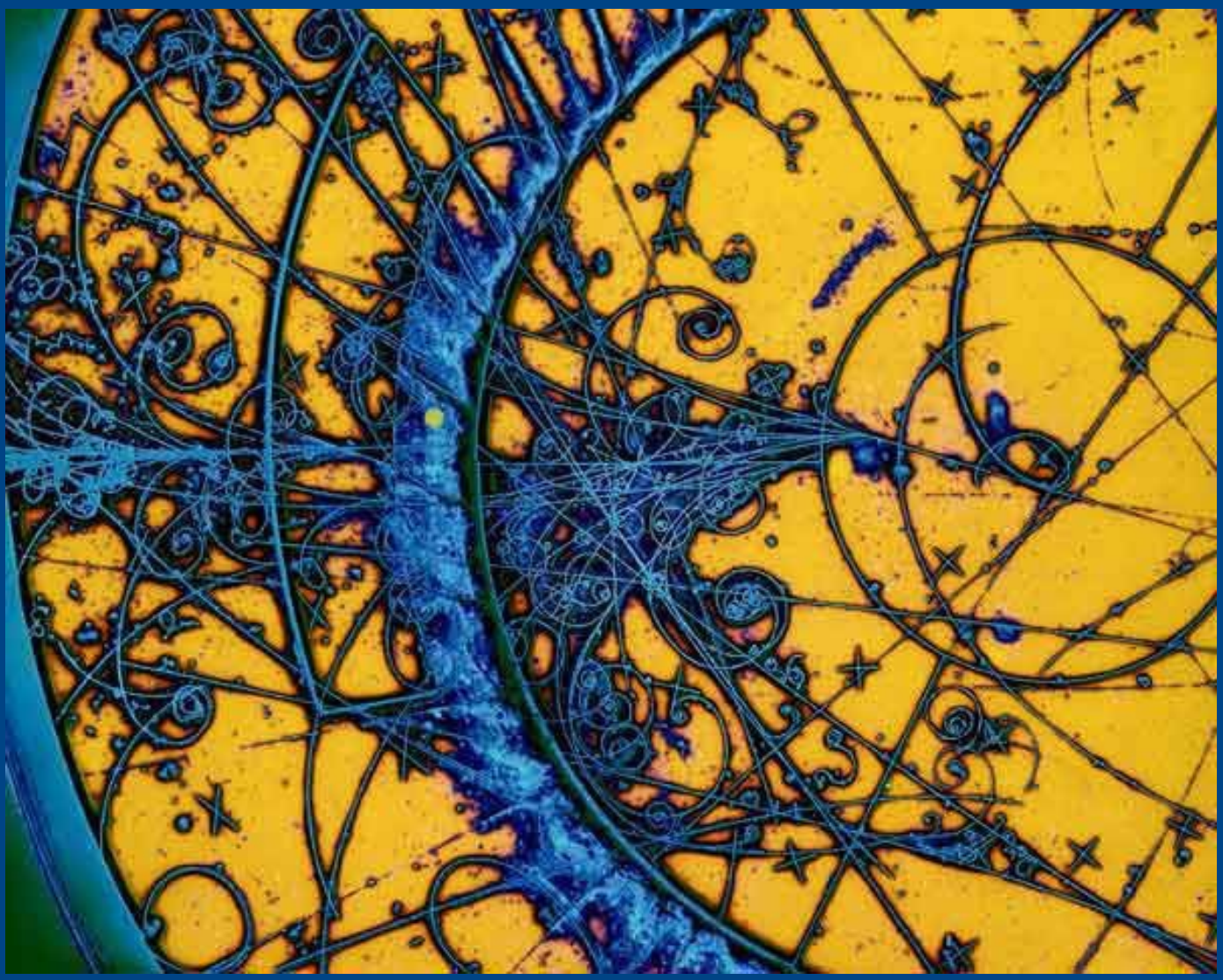
istituto nazionale di fisica nucleare
gruppo collegato di cosenza

2018
annual report



PARTICLE PHYSICS EXPERIMENTS

ATLAS Experiment

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S. Palazzo (Dott.), L. Pagnotta (Ass.), F. Pellegrino (Tecn.), A. Policicchio (Ass.),
V. Romano (Tecn.), D. Salvatore (Ass.), M. Schioppa (Ass.), M. Scornajenghi (Dott.),
A. Tarasio (Tecn.), E. Tassi (Resp.), P. Turco (Tecn.)

1 Introduction

The researchers of the ATLAS Cosenza group have been actively involved, in the year 2018, in physics analyses, covering a wide range of important topics of the LHC physics program, as well as in the Phase-I and Phase-II upgrade activities. The most relevant contributions of our group are briefly reviewed below.

2 Physics Analyses

2.1 Isolated-photons plus jet production in *pp* collisions

The production of prompt photons in association with at least one jet in proton–proton (pp) collisions provides a testing ground for perturbative QCD (pQCD). The group published in 2018 an analysis on the study of the dynamics of isolated-photon production in association with a jet in proton–proton collisions at a centre-of-mass energy of 13 TeV. The analysis was based on the 2015 dataset corresponding to an integrated luminosity of 3.2 fb^{-1}. Single differential cross sections were measured as functions of the leading-photon transverse energy, the leading-jet transverse momentum, the azimuthal angular separation between the photon and the jet, the photon–jet invariant mass and the scattering angle in the photon–jet centre-of-mass system. Both the tree-level plus parton-shower predictions from Sherpa and Pythia as well as next-to-leading-order QCD predictions from Jetphox and Sherpa were found to give an adequate description of the measurements. The experimental uncertainties are, in general, much smaller than the uncertainties in the theoretical predictions and, thus, improved higher-order calculations will allow more stringent tests of the theory.

2.2 Measurements of the cross-section for the production of a W/Z boson in association with b-jets

Measurements of the production cross section of a vector boson ($V = W$ or Z) in association with b-jets in proton-proton collision provide an important test of pQCD. Moreover these processes are sensitive to heavy flavour quarks in the initial state. A detailed knowledge of V+b-jets production is also a key element in the understanding of Higgs-boson processes, indeed they form one of the main backgrounds for the Higgs decay into a b-quark pair in associated production with a W/Z boson and they constitute also background to many other processes, from top-quark production to searches for beyond Standard Model processes including SUSY and other exotica. The studies, to which our group contributes, are conducted using data collected at the centre-of-mass energy of 13 TeV. Differential V+b-jets cross sections in several observables in a fiducial phase space are going to provide strong experimental constraints to improve the theoretical description. The group also contributes to modelling studies of inclusive V+jets and V+b-jets processes to establish the best

configuration of state-of-art Monte Carlo generators to be employed in future measurements with the aim of reducing mismodelling and related uncertainties as much as possible.

2.3 Studies of the Higgs decay into a b-quark pair in associated production with a W/Z boson

The observation of the Higgs boson at LHC has been established in the diphoton, ZZ, WW, and $\tau\tau$ decay modes with Run 1 data collected at the centre-of-mass energy of 7 and 8 TeV. The decay of the Higgs boson into b quarks ($H \to b\bar{b}$), characterized by largest decay branching fraction (about 58% within the Standard Model), has been observed only in the second part of 2018 profiting by the combination of the Run 1 data with a part of the data collected in Run 2 at the centre-of-mass energy of 13 TeV. The group contributed to this study, participating to the analysis of this decay channel in associated production with a W/Z boson (VH) using the Run 2 data. The exploration of the W/ZH topology has been the one driving the observation of this decay. The $W/ZH(\to b\bar{b})$ study also led the observation of the Higgs boson production in association with a vector boson that has been obtained combining the Run 2 results searching for the VH production mode but decaying into either two photons or four leptons or b-quarks. The group is currently involved in the second round of the $W/ZH(\to b\bar{b})$ measurements. The new measurements profiting of the larger dataset will allow a better understanding the Yukawa coupling of the Higgs boson to b quarks. Moreover the detailed studies of the production properties in combination with other decay modes measured at the LHC will provide important additional constraints on new physics beyond the Standard Model.

2.4 Measurements of the differential cross-sections for $t\bar{t}$ production

Studies of top-quark production and decay are major research goals at the LHC, providing both a precise probe of the Standard Model and a window on physics beyond the Standard Model. The measurements of the differential cross-sections for the production of $t\bar{t}$ pairs provide in particular stringent tests of QCD calculations with heavy quarks and allow a precise determination of the top-quark mass and of the proton's parton distribution functions (PDFs) in a well-defined theoretical framework. The group is actively involved in the measurements, based on the Run2 ATLAS data samples, of the particle- and parton-level single and double differential cross sections for the production of $t\bar{t}$ pairs in the semi-leptonic and fully hadronic finale states. The final measurements, whose completion if foreseen by Spring of 2019, will be presented for the resolved and boosted final state topologies. The group also contributes to phenomenological analyses that exploit the measured Run 2 double differential cross sections to determine the top quark pole mass and the PDFs.

2.5 Search for long-lived neutral particles with the ATLAS experiment at LHC

Signatures of displaced vertices or collimated lepton/light meson tracks (lepton-jets) from the decay of long-lived neutral particles (LLNP) gained considerable interest over years: LLNPs arise in several theory models, including SUSY, Hidden Sector theories and Dark Matter models that explain the open questions in modern particle physics. The group is actively involved in the development and maintenance of the signature-based triggers and of the reconstruction techniques for the selection of events with displaced vertices and lepton-jets, as well as in the analysis and the theory interpretation of the selected LHC collision data. Results based on the LHC Run1 and Run2 data have been published on major referred journals and presented at international conferences. The results based on the full Run2 13 TeV statistics (140 fb^{-1}) are expected by the end of 2019. The group is also collaborating to the organization of theory-experimental joint workshops to discuss the theory interpretation and the presentation of the experimental LHC results and set new search directions.

3 Phase-I and Phase-II Upgrades

3.1 Phase-I: Construction and test of the ATLAS-NSW SM1 modules

To benefit from the expected high luminosity of Phase-I upgraded LHC, the first station of the forward ATLAS muon spectrometer (Small Wheel, SW) will be replaced in 2020. The new detectors will operate up to 15 kHz/cm^2 with high precision as well as furnishing information for the Level-1 trigger. The new SW has two detector technologies: micromegas mainly for precision tracking and small strip TGC for mainly L1 trigger. An INFN consortium formed by Cs, LNF, Le, Na, Pv, Rm1, Rm3 has the responsibility of the construction and test of the MM modules (SM1) located in a small- sector closed to the beam line. After the construction of the first two full size MM prototypes the performances have been checked in a test-beam at CERN and in the second semester of 2017 the series production has started. In the year 2018 six complete modules have been produced and fully assembled and few of them tested at the gamma irradiation facility at CERN. In summer 2018 the preparation of the drift modules have been transferred at "Alte Energie" laboratory of Cosenza where the raw panels produced by Roma1 are cleaned, dressed with other elements (interconnection holders and spacers, mesh frames and O-Rings) and tested. Once the panels are ready they are transferred to LNF where they are completed with the mesh. The group has the responsibility of the finalization of the drift panels and of the logistic and data base of all the material need for the construction of all types of modules present in the NSW project.

3.2 Phase-II: Construction and test of the BIL RPC chamber

In the 2018 the group got the responsibility to build and test one fourth of the trigger chambers to be paired to the BIL tracking detector of the muon spectrometer. The BIL tracking chambers were built by the Cosenza Group more than 15 years ago. To increase the discrimination power for muons coming from the interaction point, the ATLAS collaboration agreed to the construction of the forth multilayer of RPC chamber to install on top of the existing BIL tracking chamber. The preparation of the laboratory and the construction of the first tools will start in the second part of the 2019 as soon as the work on the drift panels of the NSW project will be completed.

3.3 Phase-II: R&D Phase-II Atlas Pixel

Over the next decade the Large Hadron Collider at CERN will undergo a series of upgrades, increasing both the energy and the luminosity, culminating in the Phase-II upgrade that will deliver an unprecedented instantaneous luminosity of $5 \cdot 10^{34} cm^{-2} s^{-1}$ at 14 TeV centre-of-mass energy. In particular, the current Inner Tracker will need to be replaced with a new all silicon Inner Tracker (ITK) to maintain tracking performance in the high occupancy environment and to cope with the increase of approximately a factor of ten in the total radiation fluence. An intense R&D program is currently underway at CERN to develop the new sensor technologies meeting this challenge. With the support and engagement of the local research groups of Electronics and Mechanical Engineering, the Cosenza Unit participates in R&D for the second 3D generation sensor and is involved in the design, construction and tests of the ITK cooling system, coordinated by the Genoa Team. Prototypes and thermo mechanical tests are performed in the local laboratories.

4 List of Conference Talks and Posters by LNF Authors in Year 2018

1. G. Callea, "Recent Tests of QCD with the ATLAS Detector", Excited QCD 2018, Kapaonik, Serbia, 11-15 March 2018.

2. G. Carducci, "Finalization of the drift panels of the New Small Wheels project of ATLAS Phase-I", presented at the SIF Conference, Cosenza (Italy) 17-22 September 2018.

3. F. La Ruffa, "Calibration of the ATLAS b-tagging algorithm in $t\bar{t}$ semi-leptonic events", presented at the SIF Conference, Cosenza (Italy) 17-22 September 2018.

4. A. Mastroberardino, "Atlas Searches using Jet Substructure", Miami 2018, 13-19 Dicembre 2018, Fort Lauderdale (USA).

5. E. Meoni, "New results on W boson production with the ATLAS detector", Rencontres du Vietnam, 25th Anniversary, Windows on the Universe, ICISE - Quy Nhon (Vietnam), 5-11 August 2018.

6. E. Meoni, "What is published since the last Standard Model Workshop", ATLAS Standard Model Workshop 2018, Queen Mary University of London (QMUL) - London, 5-7 September 2018.

7. D. Salvatore, "Search for displaced Lepton-Jets with the ATLAS experiment", poster presented at SUSY 2018, Barcelona (Spain), 23-27 July 2018.

8. D. Salvatore, "Recent results from Susy and Exotic signatures with the ATLAS experiment", presented at LHC days, Split (Croatia) 17-22 September 2018.

9. M. Scornajenghi "Top quark differential cross-section measurement with the ATLAS detector ", XXIV Epiphany Conference on Advances in Heavy Flavour Physics, Cracow, Poland, 9-12 January 2018.

10. M. Scornajenghi "Top quark pair differential cross-section measurements in the fully hadronic channel, resolved regime, in pp collisions at sqrt(s)=13 TeV with the ATLAS Detector", poster presented at the 11th International Workshop on Top Quark Physics (TOP 2018), Bad Neuenahr, Germany, 16-21 September 2018.

11. M. Scornajenghi "Top quark pair differential cross-section measurements in pp collisions at sqrt(s)=13 TeV with the ATLAS Detector", 11th International Workshop on Top Quark Physics (TOP 2018), Bad Neuenahr, Germany, 16-21 September 2018.

KLOE2, MATHUSLA

A. Policicchio (Ass.), M. Schioppa (Resp.)

1 KLOE-2 experiment at Daphne e+e- collider

[M. Schioppa]

The KLOE-2 experiment at the INFN Laboratori Nazionali di Frascati is currently taking data at the upgraded e+e- DAFNE collider. KLOE-2 represents the continuation of the KLOE experiment with a new physics program. The KLOE detector has undergone several upgrades including state-of-the-art cylindrical GEM Inner Tracker, electron-positron taggers for the $\gamma\gamma$ - physics studies and new calorimeters around the interaction point. The group has collaborated to the data tacking until the end of the physics program and to the analysis of data.

2 MATHUSLA

[A. Policicchio, M. Schioppa]

Lifetime is a free parameter in the models predicting LLNP. The only upper limit comes from the Nucleosynthesis after Big Bang (BBN): $c\tau \sim 10^{7\div 8}$ m. Given the not optimal design of the LHC detectors to searches for particles with long life, the upper limit in lifetime reachable after the High Luminosity LHC phase (assuming an integrated luminosity of $\sim 3\ ab^{-1}$) is $\sim 10^3$ m. The Cosenza group is member of the MAssive Timing Hodoscope for Ultra Stable neutraL pArticles (MATHUSLA) collaboration. The goal is to propose a large area detector to be installed at the ground level over the ATLAS or the CMS detector to explore the lifetime frontier collecting data during the High Luminosity LHC phase. The group is contributing to the simulation studies and experimental tests on a small detector prototype that are mandatory for the preparation of the experiment proposal. Moreover the group has submitted a project to University and Research Minister (Prot. 2017CT23P7) to build a prototype of MATHUSLA to be assembled and tested in the INFN laboratory of Cosenza and then transferred to surface laboratory of CERN ATLAS experiment for operation at the LHC-Run3 where both cosmic rays and machine backgrounds can be studied extensively. At the end of the project, the telescope will continue the measurements for at least one additional year under the supervision and responsibility of the MATHUSLA collaboration.

THEORETICAL PHYSICS

BELL
Fundamental Problems in Quantum Physics

G. Nisticò (Resp.)

1 Consistent relativistic quantum theories of single particle

In order to develop the relativistic quantum theories of single free particle without the problems that plagued [1)] the theories yielded by canonical quantization [2), 3), 4)], we have pursued an approach, based on group theoretical methods, that develops the theory deductively from physical principles. These methodological commitments prevent from the inconsistencies of the early theories.

Our work has pointed out that the coherent development of the theories requires new classes of representations of the Poincaré group besides those considered by the current literature. We have derived six inequivalent complete consistent theories $\mathcal{T}.1$-$\mathcal{T}.6$ for spin 0 particles. Theories $\mathcal{T}.1$ and $\mathcal{T}.2$ coincide with the known theories with positive and negative energy, respectively. Theories $\mathcal{T}.3$ and $\mathcal{T}.4$ describe particles with symmetrical energy spectrum, and for this reason we can call them Klein-Gordon particles, but turn out to be based on irreducible representations in the new classes; they are not affected by the inconsistencies of Klein-Gordon theory. $\mathcal{T}.5$ and $\mathcal{T}.6$ are consistent theories so far unknown.

For the case of non zero spin, our approach is yet unable to determine complete theories, because of the present lack of explicit quantum transformation relations of position with respect to boosts. Such relations can be nowadays determined only in the already identified complete theories $\mathcal{T}.1$-$\mathcal{T}.6$ for spin 0 particles, where they can be directly calculated, all involved operators being explicitly known; they turn out to coincide with the transformation properties assumed by Jordan and Mukunda [5)] for all spins, we refer to as (JM). Then we have checked the consistency of (JM) with the theories developed in our approach.

As a result we found that Dirac theory is the unique theory for spin $\frac{1}{2}$ such that (JM) are satisfied; once again, it requires an irreducible representation in the new classes. This could be taken as an argument supporting the general validity of (JM). On the other hand, (JM) is inconsistent with the existence of localizable particle with positive energy and $s > 0$. Such a dilemma indicates the importance of working for an explicit determination of a generally valid transformation property of position with respect to boosts.

The results of the research, available online at `https://arxiv.org/pdf/1901.11481.pdf` and `https://arxiv.org/pdf/1811.01546.pdf`, are submitted for publication onto scientific journals.

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2. Klein O. 1926, *Z. Physik* **37** 895
3. Fock V. 1926 *Z. Physik* **37** 242

4. Gordon W. 1926 *Z. Physik* **40** 117

5. Jordan TF, Mukunda N. 1963 *Phys. Rev.* **132** 1842

GAST
Gauge and string theories

M. Rossi (Ass.)

1 Scattering amplitudes in $\mathcal{N} = 4$ Super Yang-Mills

The $\mathcal{N} = 4$ Super Yang-Mills (SYM) theory appears at one side of one example of AdS/CFT correspondence and, interestingly, shows remarkable connections with 1+1 dimensional integrable models. Recently, techniques coming from integrable systems have been used for exact computations of gluon scattering amplitudes. Technically, the amplitudes are expressed in the form of a Operator Product Expansion (OPE) and each term in the series is computable by using form factors theory, Bethe Ansatz and S-matrix bootstrap - all techniques developed and used in 1+1 integrable models. And, thanks to the AdS/CFT correspondence, such results can be tested by comparisons with string theory predictions. In the first paper cited below we concentrate on the strong coupling limit of the fermion contribution to the gluon amplitudes and rigorously show, completing and extending previous discussions, the appearance of a new effective particle in the series: the fermion-antifermion bound state, the so-called meson. We discuss its interaction in the OPE series with itself, which leads to the formation of (effective) bound states, and with the gluons and bound states of them. All together these lead the OPE series to the known AdS_5 minimal area result for the Wilson loops (which is a string prediction), described in terms of a set of TBA-like equations. In the second paper we computed the contributions to the strong coupling limit of gluon scattering amplitudes due to 'scalar' excitations. In this respect, we found crucial to consider the series not for the amplitude, but for its logarithm: operating in such a way, we could clearly show that the leading behavior is proportional to the 't Hooft coupling and give an analytic expression for the numerical coefficient. Some statements about the two subleading terms were also reported.

References

1. Alfredo Bonini, Davide Fioravanti, Simone Piscaglia, Marco Rossi,
N=4 polygonal Wilson loops: fermions,
refereed and original contribution to the proceedings of the 10th International Symposium on Quantum theory and symmetries and 12th International Workshop on Lie Theory and Its Applications in Physics (QTS-10) 19-25 Jun 2017. Varna, Bulgaria, Springer, Proc. Math. Stat. 255 (2017) 181-191, arXiv:1807.07058 [hep-th].

2. Alfredo Bonini, Davide Fioravanti, Simone Piscaglia, Marco Rossi,
The contribution of scalars to N=4 SYM amplitudes II: Young tableaux, asymptotic factorisation and strong coupling,
Nucl. Phys. B931 (2018) 19-71, arXiv:1707.05767 [hep-th].

NEMESYS
Non Equilibrium dynamics Models
and Excited state properties of low-dimensional SYStems

A. Sindona (Resp., National coord.), G. Falcone (Ass.), P. Riccardi (Ass.),
F. Plastina (Ass.), J. Settino (Dott.), F. Alessandro (Dott.)

1 Research Activity

Following its initial proposal made in 2016, the NEMESYS specific initiative (SI) has been developing models and highly demanding computational strategies to explore the excited state properties, collective excitations, transport phenomena and other many-body properties of low dimensional systems of uttermost importance both form the fundamental and practical points of views, covering range of applications spanning from nano-electronics to biomedicine. Throughout 2018, the CS unit has coordinated the activities of the four nodes involved in the SI, specifically exploring the following topics:

(i) **plasmon excitations, dielectric, electromagnetic, and fundamental properties of graphene and beyond graphene systems.** A self-consistent strategy, based on time-dependent density functional theory in the random phase approximation, was applied to several nanostructures based on Carbon, Silicon and Germanium. A new possible direction was outlined towards the synthesis of silicene, a promising material whose existence has been severely questioned in the literature. In particular, the intrinsic plasmonics of some silicene superstructures grown on sliver were scrutinized and compared with the analogous (π-like) collective oscillations of freestanding silicene. The analysis lead to the realization of a quasi-freestanding silicene-silver prototype. In addition, the role of the extrinsic (intraband and interband) plasmons of graphene nanoribbons (as narrow as about 3 nm), organized in periodic planar arrays with perfectly symmetric edges, was fully elucidated [1]. Finally, an ab initio framework was set up to determine the effective fine-structure constant of graphene, i.e., the coupling strength that emerges from the many electron interaction in the system, and characterizes the behavior of its ultrarelativistic charge-carriers. In this context, a calibration method was developed to extract this fundamental quantity from inelastic x-ray scattering measurements on crystal graphite. Then, it was demonstrated that it is possible to carry out perturbation approaches for the two-dimensional gas of massless Dirac fermions in graphene, in parallel with quantum electrodynamics [2].

(ii) **Electron correlations in atomic collisions at surfaces.** Density functional calculations were combined with scattering experiments of singly charged helium, sodium, and neon ions from polycrystalline aluminum surfaces to zoom on the Auger decay of the projectiles. On the one hand, a correlation between the autoionization of doubly excited He particles and the Auger decay of $2p$ vacancies in Al was been established. On the other hand, a double promotion of $2p$ electrons was detected in collisions involving Ne projectiles and neon-like Na ions. Accordingly, a molecular orbital promotion model was used to show that the promotion of $2p$ electron pairs anticipates the neutralization of the sodium projectiles, whereas only single excitations were eventually recorded. This observation also suggested that the electron

excitation in Na^+-Al collisions is governed by the occupancy of the $3s$ level of the projectile, with the electrons being excited into the Rydberg states of the collision system, rather than being transferred to the solid [3].

(iii) **Out of equilibrium scaling in spin systems.** A one-dimensional quantum Ising model, under sinusoidal modulation in time of its transverse magnetic field, was considered to show how the scaling of various quantities (concurrence, entanglement entropy, magnetic and fidelity susceptibility) endures up to a stroboscopic time, proportional to the size of the system. This behaviour was explained by noticing that the low-energy modes, responsible for the scaling properties, are resilient to the absorption of energy. It was, then, suggested that the relevant features of these universal scalings do hold also when the system is brought out-of-equilibrium by a periodic driving. Subsequently, a quantum probing protocol, in which a qubit is coupled to a many-body system, was set up to show how and when it is possible to perform a full momentum resolved spectroscopy using one single atomic impurity probe. It was further shown that two-point correlations can be extracted as well, by using two entangled probes [4]. Finally, the ground state properties of a cold atomic gas, loaded into a bi-chromatic lattice, were analyzed specializing to the cases of non-interacting fermions and hard-core (Tonks-Girardeau) bosons, trapped by the combination of two periodic potentials with incommensurate lattice constants [5].

Talks

05/03/2017 A. Sindona, "Terahertz conductivity of graphene-based one-dimensional systems", Politecnico di Torino (Organizer Dott.ssa Patrizia SAVI)

13/09/2018 A. Sindona , "hybridization and intrinsic plasmonics of silicon phases grown on silver", Graphene Week 2018, Donostia-San Sebastian (SPA), 10-14/09/2018, organized by prof. J. M. Pitarke (among the keynote speakers of the conference, prof. A. Geims, Nobel laureate in 2010 for the discovery of Graphene)

18/12/2018 A. Sindona, "Electromagnetic response of graphene nanoribbons in planar array configuration: a time-dependent density functional approach" Nanoscience and Nanotecnology 2018, 18-20/12/2018, Frascati (RM), Italy

18/09/2018 F. Plastina, "Work extraction from quantum systems and the thermodynamics of correlations", **invited talk** at the conference "IQIS18", Catania, 17-20 /09 2018;

19/07/2018 F. Plastina, "Thermodynamics of Classical and Quantum Correlations", **invited talk** at the conference "LPHYS2018", Nottingham (UK), 16-20 /07 / 2018,;

23/03/2018 F. Plastina, "Orthogonality catastrophe and Fano resonances in a one dimensional optical lattice", talk at the conference "QuProCS III", Oxford (UK), 21-23 /03/ 2018.

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2. M. Pisarra, A. Sindona, P. Riccardi, "*Scattering Resonances in bilayer graphene*, Journal of Phyiscs - Conference Series **987**, 012030 (2018)

3. P. Riccardi, F. Cosimo, A. Sindona, "*Absence of reionization in low-energy Na^+ scattering from Al surfaces*, Physical Review **A 97**(3), 032703- Published: MAR 8 2018

4. G. Manzano, F. Plastina, R. Zambrini, "*Optimal Work Extraction and Thermodynamics of Quantum Measurements and Correlations*", Physical Review Letters **121**(12), 120602 - Published: SEP 20 2018

5. F. Cosco, M. Borrelli, J.J. Mendoza-Arenas, F. Plastina, D. Jaksch, S. Maniscalco, "*Bose-Hubbard lattice as a controllable environment for open quantum systems* ", Physical Review **A97**(4), 040101 - Published: APR 9 2018

NPQCD
Understanding the properties of strong interactions at large distances and in extreme conditions

V. Chelnokov (Ass.), M. Gravina (Ass.), A. Papa (Resp.)

1 Dual formulation of the finite density 2d O(3) σ-model

The action of the 2d O(3) nonlinear σ-model on the lattice in a bath of particles, when expressed in terms of standard O(3) degrees of freedom, is complex. A reformulation of the model in terms of new variables that makes the action real was presented. This reshaping enabled to utilize Monte Carlo simulations based on usual importance sampling. Several observables, including the correlation function and the mass gap, were measured.

2 Talks in Year 2018

1. V. Chelnokov,
   Spatial structure of the color field in the SU(3) flux tube,
   presented at "Lattice 2018", East Lansing (MI, USA), June 22-26, 2018.

References

1. B. Alles, O. Borisenko and A. Papa,
   Finite density 2d O(3) sigma model: dualization and numerical simulations,
   Phys. Rev. D **98** (2018) no.11, 114508, doi:10.1103/PhysRevD.98.114508 [arXiv:1808.07810 [hep-lat]].

PLEXNET
Physics of Complex Networks

G. Alì (Resp.), R. Beneduci (Ass.), G. Mascali (Ass.)

1 Mathematical Models for Semiconductors

1) Study of the influence of electron-phonon interaction on the lattice thermal conductivity.

2) Study of an extended hydrodynamical model for plasmas, based on the moments of a particle distribution function which satisfies the Fokker-Planck-Landau (FPL) transport equation.

3) Study of mathematical models for the charge and heat transport in graphene, with a particular attention to the problem of defining a local non-equilibrium temperature.

4) Study of a model for charge transport in Si devices based on a mixture of 2D and 3D electrons

5) Coupled models: coupling of partial derivative equations and differential-algebraic equations, that is, PDAE (partial-differential-algebraic equations). In particular existence and uniqueness of solutions to parabolic PDAE with applications to the description of circuit integrated in semiconductors.

6) Model Order Reduction (MOR) for nonlinear DAEs with tractability index 1, with application to gas transport network.

2 Generalized quantum observables and joint measurability of quantum observables

1) **Characterizations of generalized observables.** A quantum observable is properly represented by a positive operator valued measure (POVM) of which the spectral measures are particular examples. We found the relationships between the representation of a commutative POVM as the noisy version of a spectral measure and the representation as a Choquet's integral due to S.T. Ali. We are writing a book for the Editor Springer on the Mathematical Structure and Physical meaning of POVMs.

2) **Quantum Observables and Universal Markov kernels.** It is well known that a POVM F is commutative if and only if it is the noisy version of a self-adjoint operator with the noise generated by a Feller Markov kernel. That characterizes a particular class of quantum observables. We proved that there is a universal Markov kernel, i.e., a Markov kernel ω such that every commutative POVM F is the noisy version of a self-adjoint operator A with the noise generated by ω.

3) **Joint measurability of quantum observables.** The joint measurability of the position and momentum observables cannot be represented in the framework of self-adjoint operators while it has a clear representation (which includes the Heisenberg inequality) in the framework of POVMs. We gave necessary and sufficient conditions for two generalized observables (POVMs) to be jointly measurable.

3 Congresses

1) Ecmi 2018, Budapest, Hungary, June 18-22, 2018 (G. Mascali: Organization Minisymposium + Communication)

2) XIV SIMAI Congress, Rome, Italy, July 2-6, 2018 (G. Mascali: Communication)

3) GROUP32 (The 32nd International Colloquium on Group Theoretical Methods in Physics), July 9-13, 2018, Prague, Czech Republic (R. Beneduci: Organization of a Parallel Session + Talk)

4) Assemblea Scientifica GNFM (Gruppo Nazionale di Fisica Matematica), October 4-6, 2018, Montecatini terme, Italy (R. Beneduci: Talk)

5) Quantum Cagliari 2018, Cagliari, Italy, October 8-11, 2018 (R. Beneduci: Talk)

References

1. G. Mascali, V. Romano, Heat generation and dissipation, in the Handbook of optoelectronics Device Modeling and simulation, J. Piprek Editor, Taylor & Francis Books, 2018, ISBN 9781498749466.

2. D.V. Camiola, G. Mascali, V. Romano, An improved 2D-3D model for charge transport based on the maximum entropy principle, Continuum Mechanics and Thermodynamics, already published online: https://doi.org/10.1007/s00161-018-0735-6 (2018).

3. R. Beneduci, Commutative POVMs: from the Choquet representation to the Markov kernel and back, Russian Journal of Mathematical Physics, 25 (2018) 158-182.

4. R. Beneduci, Universal Markov Kernel for Quantum Observables, Geometric Methods in Physics XXXVI workshop 2017, Trends in Mathematics, 21-29, Birkauser (2018).

QFT@COLLIDERS
Precision calculations for collider physics

A.D. Bolognino (Dott.), A. Papa (Resp.)

1 High-energy resummation in heavy-quark pair photoproduction

The inclusive production of two heavy quarkantiquark pairs, separated by a large rapidity interval, was considered in the collision of (quasi-)real photons at the energies of LEP2 and of some future electronpositron colliders. The calculation included full resummation of leading logarithms in the center-of-mass energy and partial resummation of the next-to-leading logarithms, within the BalitskyFadinKuraevLipatov (BFKL) approach.

2 Hadron-jet correlations in high-energy hadronic collisions at the LHC

The inclusive production at the LHC of a charged light hadron and of a jet, featuring a wide separation in rapidity, was suggested as a new probe process for the investigation of the BFKL mechanism of resummation of energy logarithms in the QCD perturbative series. Some predictions was presented, tailored on the CMS and CASTOR acceptances, for the cross section averaged over the azimuthal angle between the identified jet and hadron and for azimuthal correlations.

3 Unintegrated gluon distribution from forward polarized ρ-electroproduction

Some arguments were presented to support the suggestion that data on the helicity structure for the hard exclusive electroproduction of ρ mesons at HERA (and in possible future high-energy electron-proton colliders) provide useful information to constrain the transverse momentum dependence of the unintegrated gluon distribution in the proton.

4 Talks in Year 2018

1. A.D. Bolognino,
   ρ-meson leptoproduction as testfield for the unintegrated gluon distribution in the proton,
   presented at "XIX Frascati Spring School Bruno Touschek in Nuclear, Subnuclear and Astroparticle Physics", Frascati (Rome, Italy), May 7-11, 2018.

2. A.D. Bolognino,
   Leptoproduction of ρ-mesons as discriminator for the unintegrated gluon distribution in the proton,
   presented at "Diffraction and Low-x 2018", Reggio Calabria (Italy), August 26 - September 1, 2018.

3. A.D. Bolognino,
   Jet-hadron production at the LHC in NLA BFKL,

presented at "104° Congresso della Società Italiana di Fisica", Arcavacata di Rende (Cosenza, Italy), September 17-21, 2018.

4. A.D. Bolognino,
k_T-dependence of the unintegrated gluon distribution in the ρ-meson leptoproduction,
presented at "Workshop on Resummation, Evolution, Factorization 2018", Kraków (Poland), November 19-23, 2018.

5. A.D. Bolognino,
Diffractive electroproduction of ρ-meson as discriminating testfield for the unintegrated gluon distribution in the proton,
presented at "International Workshop on Multiple Partonic Interactions at the LHC", Perugia (Italy), December 10-14, 2018.

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2. A.D. Bolognino, F.G. Celiberto, D.Yu. Ivanov, M.M.A. Mohammed and A. Papa,
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Eur. Phys. J. C **78** (2018) no.9, 772, doi:10.1140/epjc/s10052-018-6253-7 [arXiv:1808.05483 [hep-ph]].

3. A.D. Bolognino, F.G. Celiberto, D.Yu. Ivanov and A. Papa,
Unintegrated gluon distribution from forward polarized ρ-electroproduction,
Eur. Phys. J. C **78** (2018) no.12, 1023, doi:10.1140/epjc/s10052-018-6493-6 [arXiv:1808.02395 [hep-ph]].

SFT - Statistical Field Theory
Low-Dimensional Systems, Integrable Models and Applications

R. Giuliano (Dott.), F. Plastina (Ass.), D. Giuliano (Resp.)

1 Edge insulating topological phases in a two-dimensional long-range superconductor

We study the zero-temperature phase diagram of spinless fermions over a two dimensional square lattice, with nearest neighbor hopping and algebraically decaying pairing. Varying the range of the pairing, we find new phases, signaled by the violation of the area law for the Von Neumann entropy, by semi-integer Chern numbers, and by edge modes with nonzero mass, which implies the absence of single-fermion edge conductivity, We discuss possible experimental realizations of our model Hamiltonian in realistic setups [1)].

2 Current transport properties and phase diagram of a Kitaev chain with long-range pairing

We propose to probe the quantum phase transition between the short-range topological phase and the long-range topological phase in the superconducting Kitaev chain with long-range pairing, by looking at the Fano factor measured when the chain is connected to leads biased at a voltage V. We find that the Fano factor is either zero (in the short-range correlated phase) or 2e (in the long-range correlated phase) and, thus, that it works as a directly measurable quantity to probe the quantum phase transition between the two phases. [2)].

3 Josephson Current Anomalies in Spin-Orbit Nanowires

We study the anomalous Josephson effect in a nanowire with Rashba spin-orbit interaction and Zeeman spin splitting, contacted with two s-wave superconducting leads with either one or two open conducting channels in the wire, showing that, in both cases, the Josephson current is zero at an applied phase different from both 0 and pi. Moreover, we observe an asymmetry in the critical current in the two directions up to about 20% [3)].

4 Anomalous Josephson Effect in S/SO/F/S heterostructures

We study the anomalous Josephson effect and the dependence on the direction of the critical Josephson current in an S/N/S junction, with the normal part alternatively containing spin-orbit coupled and ferromagnetic layers. We show that to observe these effects it is sufficient to break spin rotation and time reversal symmetry in spatially separated regions of the junction. Eventually, we discuss how to further improve these effects by engineering multilayers structures with more that one couple of alternating layers [4)].

5 From Kondo effect to weak-link regime in quantum spin-1/2 spin chains

We analyze the crossover from Kondo to weak-link regime by means of a model of tunable bond impurities in the middle of a spin-1/2 XXZ Heisenberg chain. This allows us to estimate the Kondo length by combining perturbative renormalization group approach with the exact numerical calculation of the integrated real-space spin-spin correlation functions. We show that the Kondo length takes values within the reach of nowadays experimental technology in ultracold-atom setups. In the case of non-symmetric Kondo couplings and/or spin parity broken by a nonzero magnetic field applied to the impurity, we discuss how Kondo screening redistributes among the chain as a function of the asymmetry, which eventually induces a crossover from Kondo impurity to weak-link physic [5].

6 Information flow in a Bose-Hubbard lattice

We investigated the open dynamics of an atomic impurity embedded in a one-dimensional Bose-Hubbard lattice, and derived the reduced evolution equation for the impurity, showing that the Bose-Hubbard lattice behaves as a tunable engineered environment. Indeed, it allows one to simulate both Markovian and non-Markovian dynamics in a controlled and experimentally realizable way. Furthermore, we were able to demonstrate that the presence or absence of memory effects is a signature of the nature of the excitations induced by the impurity in the lattice, which are either delocalized or localized in the two limiting cases of a superfluid and Mott insulator, respectively. Our findings show how the excitations supported in the two phases can be characterized as information carriers [6].

7 Thermodynamics of Quantum Measurement and Quantum Correlations

Building on our previous works in which we identified the role of quantum correlations in work extraction from quantum systems, we analyzed the role of indirect quantum measurements in the same processes applied to quantum systems in nonequilibrium states. In particular, we focused on the work that can be obtained by exploiting the correlations shared between the system of interest and an additional ancilla, where measurement backaction introduces a nontrivial thermodynamic tradeoff. We presented optimal state-dependent protocols for extracting work from both classical and quantum correlations, the latter being measured by discord. Our quantitative analysis establishes that, while the work content of classical correlations can be fully extracted by performing local operations on the system of interest, accessing work related to quantum discord requires a specific driving protocol that includes interaction between system and ancilla [7].

8 Publications

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1. L. Lepori, D. Giuliano, and S.Paganelli, *Edge insulating topological phases in a two-dimensional long-range superconductor*, Phys. Rev. B 97, 041109(R) (2018).

2. D. Giuliano, S. Paganelli, and L. Lepori, *Current transport properties and phase diagram of a Kitaev chain with long-range pairing*, Phys. Rev. B 97, 155113 (2018).

3. G. Campagnano, R. Giuliano, D. Giuliano, P. Lucignano, and A. Tagliacozzo, *Josephson Current Anomalies in Spin-Orbit Nanowires*, IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, vol. 28, p. 1-5 (2018).

4. M. Minutillo, D. Giuliano, P. Lucignano, A. Tagliacozzo, and G. Campagnano, *Anomalous Josephson Effect in S/SO/F/S heterostructures* , Phys. Rev. B 98, 144510 (2018).

5. D. Giuliano, D. Rossini, and A. Trombettoni, *From Kondo effect to weak-link regime in quantum spin-1/2 spin chains* , Phys. Rev. B 98, 235164 (2018).

6. F. Cosco, M. Borrelli, J. J. Mendoza-Arenas, F. Plastina, D. Jaksch, S. Maniscalco, "*Bose-Hubbard lattice as a controllable environment for open quantum systems*", Phys. Rev. A **97**, 040101(R) (2018).

7. G. Manzano, F. Plastina, R. Zambrini, "Optimal work extraction and thermodynamics of quantum measurements and correlations", Phys. Rev. Lett. **121**, 120602 (2018).

9 Talks

27/04/2018 D. Giuliano, "Effects of a Majorana mode at a junction between a topological superconductor and quantum nanowire", **Invited talk** at the conference "30 Years of AKLT - Interacting Systems in Low Dimensions", Vancouver (CANADA), 26-28/04/2018;

18/04/2018 D. Giuliano, "Chirality and Current-Current Correlation in Fractional Quantum Hall Systems", **Invited talk** at the conference "Transport in Strongly Correlated Quantum Systems", Natal (RN - BRASIL), 16/07-03/08/2018;

18/09/2018 F. Plastina, "Work extraction from quantum systems and the thermodynamics of correlations", **invited talk** at the conference "IQIS18", Catania, 17-20 /09 2018;

19/07/2018 F. Plastina, "Thermodynamics of Classical and Quantum Correlations", **Invited talk** at the conference "LPHYS2018", Nottingham (UK), 16-20 /07 / 2018;

23/03/2018 F. Plastina, "Orthogonality catastrophe and Fano resonances in a one dimensional optical lattice", talk at the conference "QuProCS III", Oxford (UK), 21-23 /03/ 2018.

TECHNOLOGICAL RESEARCH EXPERIMENTS

INSIDE Activities Report
flIcher Noise Studies for Investigation of Detector pErformances

A. Papa (Resp.), D. Fiore (Dott.)

The project INSIDE, developed in collaboration between INFN LNF - Gruppo Collegato di Cosenza and INFN Napoli, investigates the noise degradation mechanism on CMOS Single Photon Avalanche Diodes (SPADs). In particular, Dark Count Rate (DCR) and its discrete fluctuations, known as Random Telegraph Signal (RTS), have been investigated in detail after proton irradiation in two different SPAD layouts fabricated in a 150 nm CMOS process. The layouts are characterized by different junctions, P+/Nwell and Pwell/Niso junction, described in detail in [1].
DCR and RTS are due, not only to defects introduced in the semiconductor lattice and oxides during the technologic process, but even to the defects introduced in silicon structure by radiation environment. Each defect is associated to new energy level in the bandgap, that causes the generation of carriers in depletion region through both thermal (Shockley Read-Hall, SRH) and tunneling process [2, 3, 4].
In order to characterize SPAD device before irradiation, DCR measurements have been performed in climatic chamber in the range 10 - 40 °C. These measurements allowed to extract activation energy by 60 P+/Nwell junction pixels and 160 Pwell/Niso junction pixels, obtaining respectively 0.35 and 0.50 eV. In both layouts, the activation energy decreases by increasing dark count rate. This behaviour proves a clear evidence of electric field enhancement effects, as reported in [5]. The activation energies are lower than the mid band gap value (1.12 eV), the classical SRH activation energy evaluated without electric field enhancement [6, 7]. Therefore, this means that electric field enhancement mechanisms, such as Poole Frenkel effects, are involved in the physics of the DCR generation, resulting in the decrease of the barrier to tunnel through. In particular, P+/Nwell junction shows a lower activation energy with respect to Pwell/Niso junction. Indeed, the higher doping concentrations and the smaller junction dimension in P+/Nwell junction creates higher electric field in the multiplication region.
After proton irradiation, performed in LNS - INFN in Catania in March 2018, RTS has been analysed through measurements performed in climatic chamber at 20 °C for one hour per pixel. A higher RTS occurrence probability has been observed in P+/Nwell with respect to Pwell/Niso layout, suggesting that more intense electric fields in in P+/Nwell junction could result in higher RTS occurrence.
The measurements of main RTS properties for the two layouts allowed to study, not only the influence of electric field on RTS behaviour, but also to have a guess for defect types that cause RTS switching of DCR. The identification of defects responsible for RTS could be very useful to understand DCR fluctuations and to limit the effect on the devices in radiation environment. The activation energies for time constants allows to identify the defect responsible for RTS since it indicates the barrier height in potential energy to go from one configuration to another [8]. The activation energies for time constants in bi-level RTS have been evaluated around 0.8 - 1 eV for both layouts. Among different explanations of RTS origin found in literature [9-12], the reorientation of phosphorus-vacancy (P-V) center, is considered one of the defects responsible for RTS phenomenon [12]. In this case, the time constants between high and low level should depend on the kinetics of reorientation of P-V center, calculated by Watkins and Corbett as 0.93 eV. The

time constants measured for bi-level RTS pixels studied in this work could be comparable in first approximation with the kinetics of P-V center reorientation. However, the error with respect to the value calculated by Watkins and Corbett and the limited number of analysed pixels, indicate that further measurements on a large amount of pixels need, in order to better identify the defect involved in RTS.
Moreover, in December 2018, in order to compare RTS coming from defects due to different irradiation sources, gamma irradiation has been performed in Cobalt-60 irradiator in Bologna at Displacement Damage Dose (DDD) equivalent to DDD reached during proton irradiation. Data are still under investigation. The next INSIDE activity aims to perform electron irradiation test in a research facility in Warsaw in order to investigate electron damage effects and to compare RTS obtained in three equivalent irradiation tests, with protons, gamma and electrons.

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COMPUTATION TECHNOLOGY

The ReCaS Cosenza Data Center

N. Guarracino (Ass.), A. Tarasio (Ass.), E. Tassi (Resp.)

1 Introduction

The ReCaS Cosenza Data Center (see Fig. 1) represents a unique IT infrastructure in the Calabria region. A medium-sized Data Center, funded with a total budget of 1.3 M€, is characterized by an efficient, scalable and state-of-the-art support infrastructure that guarantees very high operational standards. Its present computing and storage resources (more than 1.2 PB raw storage capacity and 3500 cores) contribute in a substantial way, jointly with the other ReCaS Data Centers, to the computing needs of all the experiments at the LHC as well as others diverse scientific communities.

Figure 1: *(Left) The two-Chiller sytem (with integrated free cooling) installed at the ReCaS Cosenza Site. (Right) The white space and the racks (with LCPs) hosting part of the IT equipment.*

2 Performance

Completed by the end of 2015, and operational since then, the ReCaS Cosenza Data Center has operated also for the year 2018 with very high efficiency and stability. As an example, Fig. 2 shows

for the ATLAS virtual organization a comparison, in terms of slots of running Grid jobs and wall clock consumption, of the performance of the ReCaS Cosenza Data Center with that of the Italian ATLAS Tiers 2 and 3 sites for year 2018; the comparison demonstrates the excellent performance of the ReCaS infrastructure. The Data Center had an equally good performance, although for a presently limited number of IT resources, for the grid jobs of the Belle II collaboration.

A detailed technical description of the ReCaS Data Centers as well as of the scientific results, achieved within the adopted grid- and cloud-based open software solutions in different scientific domains, can be found in the monographic volume published by World Scientific [1].

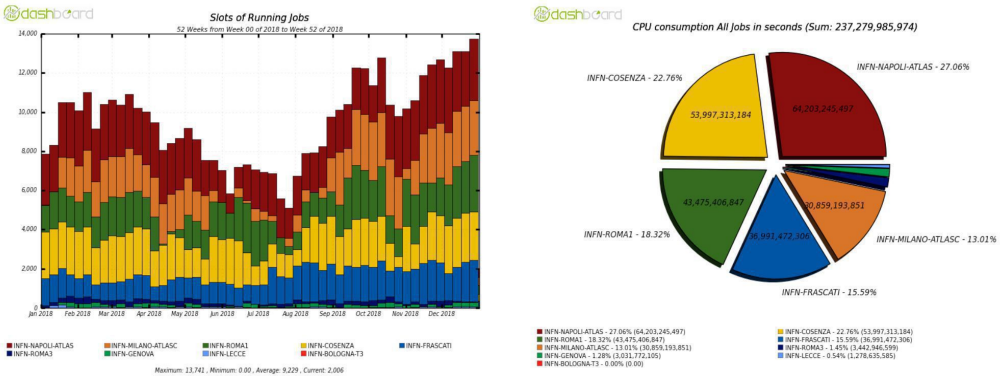

Figure 2: *A comparison of the (left) slots of running jobs and (right) wall clock consumption for the ATLAS Tier2 centers and the ReCaS Cosenza Data Center.*

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COMMUNICATION AND OUTREACH

European Researchers' Night 2018

A.D. Bolognino (Dott.), M. Capua (Resp.), G. Crosetti (Ass.), L. La Rotonda (Ass.),
F. La Ruffa (Dott.), E. Meoni (Ass.), J. Orbe (Dott.), A. Papa (Ass.), C. Petronio (Ass.),
M. Rossi (Ass.), M. Scornajenghi (Dott.), F. Stabile (Tecn.), A. Tarasio (Tecn.), E. Tassi (Ass.)

A stand was created for the 2018 researchers' night. At the stand, posters and a brochure about INFN and its research activities were distributed, sketches and interviews were made. In particular, three events were organized that turned out to be very successful:

Measurements of activity concentration of radon gas in spring water intended for human consumption Groups of students or citizens were able to visit the laboratory of the Physics Department dedicated to research activities in environmental physics and health, and to know about problems such as the presence of the radioactive radon-222 gas in the environment and its effect on health. Guests were invited to bring a sample of spring water and perform explorative measurements of activity concentration of radon gas.

Find the quarks! The fascinating world of particle physics introduced with a game. Little girls and boys who reached the stand were invited to try to compose particles made of quarks (e.g. protons and neutrons) finding the appropriate constituents. Those who managed to compose a particle within three minutes received the certificate of *Promise of particle physics 2018*.

Flair for particles! After a brief introduction to particle physics, CERN and the ATLAS experiment, it was shown how the sophisticated technology with which the ATLAS detector was made allows to observe particles. At the end of the short presentation, students took part in the search for particles, observing 15 events collected by the ATLAS experiment and trying to recognize all the particles present in each event.

International Physics MasterClasses 2018

M. Capua (Resp.), M. Del Gaudio (Dott.), L. La Rotonda (Ass.),
F. La Ruffa (Dott.), E. Meoni (Ass.), A. Olivieri (Stud.), S. Palazzo (Dott.),
A. Papa (Resp.), R. Pungitore (Stud.), P. Riccardi (Ass.), M. Rossi (Ass.), D. Salvatore (Ass.),
M. Scornajenghi (Dott.), F. Stabile (Tecn.), A. Tarasio (Tecn.), E. Tassi (Ass.)

In partnership with the IPPOG Masterclasses International Project and with the collaboration of the Physics Department of the University of Calabria, the INFN Group of Cosenza organizes, since 2013, the Physics MasterClasses for high-school students from the whole Calabria Region.

In 2018 two one-day events took place:

- February 12, special event for the International Day of Women in Science, 37 students from 13 schools (agenda.infn.it/event/mcg2018cs)

- March 14, standard events, 47 students from 23 schools (agenda.infn.it/event/mc2018cs)

with an overall enthusiastic participation of students and high-school teachers, as confirmed by the interviews.

Laboratory activities for and with schools

G. Carducci (Dott.), M. Del Gaudio (Dott.), V. Romano (Tecn.),
M. Schioppa (Resp.), P. Turco (Tecn.)

Teaching the law of Universe to the students of secondary schools using Cosmic Rays

Is out of doubt that learning by doing is the most powerful method to teach physics to young and less young students. The group has started more than 10 years ago to open the "Alte Energie" laboratory to students and to go into the schools to make experiments to measure the cosmic ray flux and the muon mean life time, but also to demonstrate the existence of cosmic ray showers at earth surface. In 2010 the group agreed to participate in the EEE (Extreme Energy Events) project, under the convincing push of Dr. R. Baldini Celio Ferroli, director of this project of Centro Fermi. The EEE project is dedicated to the study of Extensive Atmospheric Showers through a network of muon telescopes, installed in High Schools, with the main objective of introducing young students to particle and astroparticle physics, making them participate in the construction detectors at CERN and involving them in the operation and monitoring of EEE stations. Each telescope is a tracking detector composed of three Multi-Gap Resistive Plate Chambers with an active area of 1.60 0.80 m. Their characteristics are similar to the ones built for the Time Of Flight array of the ALICE Experiment at LHC. At present more than 50 MRPCs telescopes are operative spread across Italy. The inhomogeneous grid of telescopes allows a multiple, thrilling approach to the study of cosmic rays. Single detector: the EEE telescope is a high precision tracking detector that can study the flux of secondary cosmic muons, their arrival directions and upward-going particles. Cluster of detectors: in a radius of few kilometers they can study the properties of the EAS in which muons are originated; eventually an array, using sites far apart, makes it possible to investigate time correlations between EAS events. In 2018 the third telescope has been installed in Liceo Patrizi of Cariati and the forth has been approved by Centro Fermi for Liceo Fermi of Reggio di Calabria. The EEE telescopes activities into the schools are only a part of the group activities. The group organizes seminars, masterclasses, participate to the ICD and to the program ASL (work-school alternation) where the students work both into they laboratories and in the "Alte Energie" laboratory. In June, the group presented a request for participation in the OCRA project to the INFN-CC3M scientific group. The request was welcomed and will be approved at the beginning of 2019.

Premio Asimov 2018

G. Alì (Ass.), A. Papa (Resp.), M. Rossi (Ass.)

The INFN group of Cosenza has joined since 2018 the "Premio Asimov" initiative (web site: https://asimov.gssi.it/) and coordinates the related activities in the Region Calabria.

Established in 2015 by the Gran Sasso Science Institute (GSSI) of L'Aquila, the "Asimov Prize for scientific popular publishing" aims at bringing young generations closer to science through the critical reading of works of scientific divulgation. It was born from an idea by Francesco Vissani and is inspired by the prizes awarded by the Royal Society for books on scientific divulgation.

The award is named after the writer Isaac Asimov, author of numerous scientific publications as well as several novels and stories. It is aimed at high-school students who were directly involved both as jurors, since they had to rate the best scientific books published during the year before, and as competitors, since the best among their reviews were rewarded during the closing ceremony on October 5 at GSSI.

The edition of 2018 counted overall about 2300 participants from the Regions Abruzzo,

Marche, Puglia, Sardinia, Sicily, Umbria and, of course, Calabria, which contributed with about 100 students from six different high schools. On April 21 a local ceremony at the Physics Department of the University of Calabria took place, with the participation of some of the Calabrian students to be rewarded as best reviewers.

RADIOLAB 2018

M. Capua (Resp.), L. La Rotonda (Ass.), P. Riccardi (Ass.), J. Orbe (Dott.)

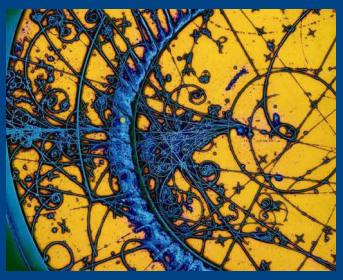
The INFN Group of Cosenza, since 2017, participates to the RADIOLAB scientific dissemination project, aimed at high-school students, and in which the INFN Units of Cagliari, Catania, Lecce, LNS, Milan, Naples, Siena, Trieste, Turin also participate.

The aim of the project is to integrate didactics with scientific communication and research on radioactivity, with special emphasis on the radon gas. Students are directly involved in laboratory activities, following the footsteps of researchers in the field and making measurements in their territory (schools but also homes or facilities considered by them of interest as far as radon risk is concerned). This project has immediate consequences in terms of dissemination of the contribution of the scientific approach to the assessment of the problem, social awareness, risk awareness, both for students and families and the society connected to them.

Four schools were involved (113 students) and more than 1500 interviews were made at the beginning of the activity to citizens to understand the degree of knowledge of the radon risk.

Our group contributed also to the realization of a summer school on Mount Rosa. The experience was a great success, as also documented in the presentation at the SIF2018 Congress ("Summer School of the Radon Laboratory for Secondary School", Groppi F., Bazzocchi A., Manenti S., Immé J., Pugliese M., Fanti V., Capua M., Ventura A., Montalbano V., Chiosso M., Budinich M.).

On November 7, Marie Skłodowska Curie's birthday, at the Liceo Fermi in Cosenza, a mini-Workshop was held for all Calabrian students involved in the project and local personalities and experts to discuss the Radon problem with particular attention to the Calabrian territory.



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