PARTICLE PHYSICS EXPERIMENTS

ATLAS Experiment

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1 Introduction

The researchers of the ATLAS Cosenza group have been actively involved, in the year 2021, 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 Analysis

2.1 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 inclusive production of $t\bar{t}$ pairs allow, in particular, tests of pQCD calculations with heavy quarks and a precise determination of the top-quark mass and of the proton's parton distribution functions (PDFs) in a well-defined theoretical framework. In the year 2021 the group has been actively involved in the measurements, based on the full Run 2 ATLAS data sample, of the particle- and parton-level differential cross sections for the production of $t\bar{t}$ pairs in the lepton+jet finale state. The paper describing the particle level analysis is now at the editorial board stage while the publication of the parton level analysis is expected for the end of 2022.

The group has also contributed to a phenomenological analysis [1] at the next-to-next-to-leading order in pQCD for the determination of a new set of proton parton distribution functions using diverse measurements in pp collisions at $\sqrt{s}$=7, 8 and 13 TeV, performed by the ATLAS experiment at the Large Hadron Collider, together with deep inelastic scattering data from ep collisions at the HERA collider.

2.2 Measurement of the b-jet identification efficiency using one-lepton boosted $t\bar{t}$ events

The identification of jets initiated by a b-quark is a crucial ingredient for many physics analyses of the ATLAS experiment. The group has contributed a novel method to calibrate the b-jet identification efficiency for b-jets at high transverse momentum, extending the coverage of existing calibrations by using boosted one-lepton $t\bar{t}$ events. The proton-proton collision data recorded between 2015 and 2018 by the ATLAS detector at the Large Hadron Collider, are used, representing an integrated luminosity of 139 fb^{-1}. The method relies on efficiently selecting boosted $t\bar{t}$ events by the identification of a large-radius ($R = 1.0$) jet, and the subsequent construction of an event-level variable independent on the b-tagging information, allowing to constrain simultaneously the flavor

composition and the b-jet identification efficiency. An ATLAS public note [2] has been released in 2021.

2.3 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 flavor 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-the-art Monte Carlo generators to be employed in future measurements with the aim of reducing mis-modelling and related uncertainties as much as possible. After the first publication done analysing 36 fb^{-1} of proton-proton data at $\sqrt{s} = 13$ TeV, the group is now involved in the extension of the measurement to the full Run-2 dataset, representing an integrated luminosity of 139 fb^{-1}. The larger amount of data allows to explore more extreme phase spaces and to improve the precision of the previous measurements.

2.4 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 reconstruction techniques (reconstruction of the displayed vertex) 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 editorial board for the analysis based on the full Run2 13 TeV statistics (140 fb^{-1}) was required. The group has started to participate to the muon chamber timing for better reject cosmic rays. 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 and their integration

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 2021. 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

their 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 2020 all SM1 modules have been produced, fully assembled, tested and shipped to CERN [3], where in 2021 they were integrated in the mechanical structure and installed in the experiment. At CERN, the group was responsible for the gas tight validation of all the micromegas chambers, as well as the HV testing and for their validation at the gamma irradiation facility at CERN. During the 2021 the group was responsible for the long term gamma irradiation of some chambers fed with a ternary gas mixture Ar:CO2-iso-C4H10 (93:5:2). The group had the responsibility of the preparation, test and finalization with the mesh of the drift panels and of the logistic and data base of all the material needed for the construction of all types of modules present in the NSW project. Figure 1 shows the wheel A (ii), its place in the ATLAS apparatus (i) and the composition of one large sector (iii).

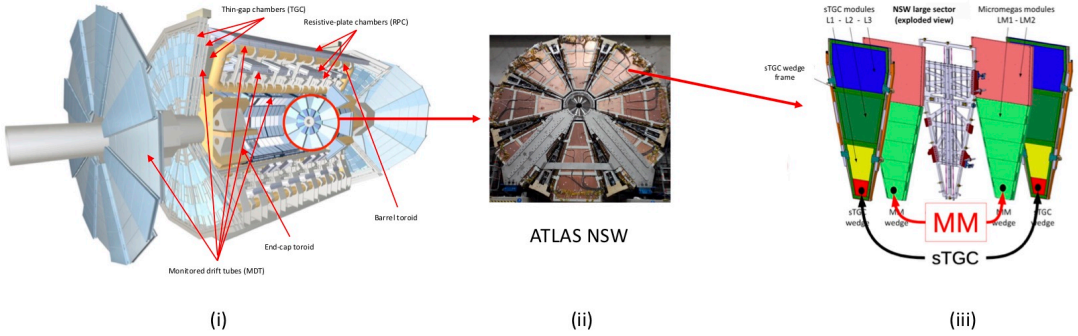

Figure 1: *The ATLAS apparatus (i), the NSW (ii) and the composition of one large sector (iii).*

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

In the 2020 the group got the responsibility to build and test the read-out panels 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 16 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 and BIS tracking chamber. During the year 2021 the group build and tested 12 prototypes of the new RPC read-out panel, which were then sent to CERN for electric and mechanic tests.

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 Genova Team. Prototypes and thermo mechanical tests are performed in the local laboratories.

4 List of Conference Talks and Poster by LNF Authors in Year 2021

1. E. Bisceglie, Study of cosmic rays with the ATLAS detector at LHC, 106 Congresso Nazionale SIF 2021, 13-17 September 2021

2. E. Bisceglie, Study of cosmic rays with the ATLAS detector at LHC, Workshop ATLAS Italia Young, 27-29 September 2021

3. F. Curcio, Update of the EvtGen decay models and branching ratios, together with masses tables for heavy flavour hadrons decay, 106 Congresso Nazionale SIF 2021, 13-17 September 2021

4. F. Curcio, NNLO predictions for $t\bar{t}$ production in the ℓ+jets final state, Workshop ATLAS Italia Young, 27-29 September 2021

5. G. Falsetti, Test di invecchiamento delle camere Micromegas di ATLAS alla sorgente GIF++ del CERN con la Miscela Ar:CO2 e AR:CO2-Iso-C4H10, 106 Congresso Nazionale SIF 2021, 13-17 September 2021

6. G. Falsetti, Long Term Irradiation Test on MicroMegas Chambers of ATLAS New Small Wheel at GIF++ Source of CERN with Ar:CO2 and Ar:CO2 :Iso-C4H10 Mixtures, Workshop ATLAS Italia Young, 27-29 September 2021

7. D. Malito, Differential $t\bar{t}$ cross-section measurements in the lepton + jets channel, 106 Congresso Nazionale SIF 2021, 13-17 September 2021

8. D. Malito, Differential $t\bar{t}$ cross-section measurements in the lepton + jets channel, Workshop ATLAS Italia Young, 27-29 September 2021

9. M. Schioppa, Misura e calcolo della resistenza elettrica delle strip resistive delle camere micromegas di ATLAS, 107 Congresso Nazionale SIF 2020, 13-17 September 2021

10. I. Gnesi, Gas and irradiation studies for the Micromegas detectors of the ATLAS New Small Wheel, 2021 IEEE Nuclear Science Symposium and Medical Imaging Conference and 28^{th} Int. Symposium on Room-Temperature Semiconductor X-Ray & Gamma-Ray Detectors, 16 - 23 October 2021

References

1. ATLAS Collaboration, "Determination of the parton distribution functions of the proton using diverse ATLAS data from pp collisions at $\sqrt{s} = 7$, 8 and 13 TeV", arXiv:2112.11266 [hep-ex], submitted to EPJC.

2. ATLAS Collaboration, "Measurement of the b-jet identification efficiency for high transverse momentum jets in $t\bar{t}$ events in the lepton + jets channel with the ATLAS detector using Run 2 data", ATL-PHYS-PUB-2021-004, available at https://cds.cern.ch/record/2753734.

3. J. Agarwala et al., "Construction and test of the SM1 type Micromegas chambers for the upgrade of the ATLAS forward muon spectrometer", submitted to Nuclear Inst. and Methods in Physics Research, A.

KLOE-2 and MATHUSLA

M. Schioppa (Resp.), F. Curciarello (Ass.)

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

The KLOE-2 experiment at the INFN Frascati National Laboratories collected data at DAFNE e^+ e^- collider up to a few years ago. KLOE-2 represents the continuation of the KLOE experiment with a new physics program and with several detector upgrades. These upgrades include 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.

1.1 Measurement of the $\pi^0 \to \gamma\gamma$ width with KLOE-2 High Energy Taggers

The measurement of the $\pi^0 \to \gamma\gamma$ width is considered an important test of the strong interaction dynamics at low energy and is one of the goals of the KLOE-2 experiment. A way to achieve a precision able to test theory predictions is to exploit the π^0 production through $\gamma\gamma$ fusion in the $e^+e^- \to e^+e^-\gamma^*\gamma^* \to e^+e^-\pi^0$ reaction. To reduce the background from ϕ-meson decays, two High Energy Tagger (HET) stations have been installed in the DAΦNE machine layout in order to tag off-energy leptons scattered in the final state. The $\gamma\gamma \to \pi^0$ signal is expected in the coincidence window between HET and KLOE while the remaining buffer depth, acquired together with the coincidence sample, is used to evaluate the amount of uncorrelated time coincidences between the two detectors (accidentals). The accidental background is modeled using the HET data acquired out of coincidence window with the KLOE detector, while the $\gamma\gamma \to \pi^0$ signal is taken from the Ekhara simulation interfaced with the BDSIM transport of the leptons through the beam line. Statistical evidence of correlated coincidence events between the electron tagger station and the KLOE calorimeter has been observed on a sample of 3 fb^{-1} with a precision of 10% and in a KLOE-HET coincidence window of few bunches. A first evidence of π^0 production from $\gamma\gamma$ scattering has been also obtained on the positron side.

2 MATHUSLA

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.

EIC_net

M. Capua (Ass.), S. Fazio (Resp.), E. Tassi (Ass.)

1 The Electron-Ion Collider and the proposed ATHENA detector

The Electron-Ion Collider (EIC)is a major new research facility to be built at Brookhaven National Laboratory (BNL) in partnership with Thomas Jefferson National Accelerator Facility (JLAB) in the U.S.A. The EIC is designed to advance the long-term vision for Nuclear Physics to discover and understand the emergent phenomena of Quantum Chromo-Dynamics. following a call for detectors proposals in 2021, three experiments have been proposed: ATHENA, ECCE, and CORE, and proto-Collaborations or Consortia have formed.

In the year 2021, Cosenza's group has joined the EIC Users' Group [M. Capua, Institutional Representative (I.R.)] and the ATHENA proto-Collaboration [S. Fazio, I.R.]. At the same time, we have also joined the INFN EIC_net initiative and participated to the "giornata nazionale" in Turin, December 2021. Within EIC_net, in March we have finalized the EIC "yellow Report" [2] outlining the requirements for an EIC detector [S. Fazio editor of several sections]. Cosenza's group became involved in the Simulation & physics Working Group [S. Fazio, co-coordinator]. This group puts together INFN-associated researchers involved or interested in the software, Monte Carlo simulation and physics performance studies at EIC, in order to discuss the coming developments.

Within the ATHENA proto-Collaboration, in year 2021, Cosenza's group played a leading role within Exclusive & Tagging Physics Working Group [S. Fazio, co-coordinator of the PWG]. This group carried on all the related performance studies that were a key part of the submitted proposal [1]. An overview paper summarising the most important studies by the ATHENA Exclusive & Tagging PWG is now in preparation.

1.1 E*p*IC - a novel event generator

S. Fazio originally proposed a joint effort with key collaborators at BNL, CEA-Saclay, NCBJ-Warsaw, Mainz and Zagreb Universities with the objective to develop a Monte Carlo event generator for exclusive processes, based on most recent extractions of GPDs. In 2021, we have developed a generator called E*p*IC, soon to be released and described in a forthcoming publication, which features a novel architecture based on the modular programming paradigm. In this way, the code structure is as simple as possible and the addition of new developments, such as new channels or models, is made as easy as possible. The architecture of E*p*IC is based on that of the PARTONS framework [Eur. Phys. J. C **78** (2018) no.6, 478]. PARTONS is also used to evaluate the Born cross-section for a given process, which is used to generate MC events after the inclusion of radiative corrections. A prototype version of the E*p*IC generator has been used to perform the studies of Deeply Virtual Compton Scattering (DVCS) and Time-Like Compton Scattering (TCS) that appear in the submitted ATHENA proposal.

References

1. The ATHENA Collaboration, "ATHENA Detector Proposal - A Totally Hermetic Electron Nucleus Apparatus proposed for IP6 at the Electron-Ion Collider", December 1, 2021. Document not yet released for the public.

2. R. Abdul Khalek, A. Accardi, J. Adam, D. Adamiak, W. Akers, M. Albaladejo, A. Al-bataineh, M. G. Alexeev, F. Ameli and P. Antonioli, *et al.* "Science Requirements and Detector Concepts for the Electron-Ion Collider: EIC Yellow Report," [arXiv:2103.05419 [physics.ins-det]].

THEORETICAL PHYSICS

BELL
Fundamental Problems in Quantum Physics

G. Nisticò (Resp.)

1 Consistent derivation of relativistic quantum theories of single particle

Relativistic quantum theories obtained by canonical quantization turned out to be plagued by serious consistency problems; e.g., Klein-Gordon theory predicts negative values of probability densities. This was one important reason that prompted Theoretical Physics to turn on Quantum Field Theory to model particle physics.

In order to develop relativistic quantum theories of single free particle without the problems that plagued the early theories, we undertook an approach, based on group theoretical methods, that develops the theories deductively from two physical principles: *invariance ot the theory under Poincarè group* and *covariance of the position observable*. These methodological commitments prevent from the mentioned inconsistencies. In so doing, six inequivalent complete consistent theories for spin 0 and positive mass particles have been derived [1)], among which the theories for particles of Klein-Gordon kind, but free from inconsistencies.

Now we have specialized [2)] to the case of *elementary massless systems*. Current theories of massless free particle assume *unitary* space inversion and *anti-unitary* time reversal operators. In so doing robust classes of possible theories are discarded. In deriving the quantum theories of massless systems through our strictly deductive development from the principle of relativistic invariance, a kind of space inversion or time reversal operator is ruled out only if it causes inconsistencies. As results, new classes of consistent theories for massless isolated systems are explicitly determined. On the other hand, the approach determines definite constraints implied by the invariance principle; they were ignored by some past investigations that, as a consequence, turn out to be not consistent with the invariance principle. Also the problem of the *localizability* for massless systems is reconsidered within the new theoretical framework, obtaining a generalization and a deeper detailing of previous results.

References

1. Nisticò G. 2020 *Group Theoretical Derivation of Consistent Free Particle Theories*, Foundations of Physics (2020) 50:977–1007 https://doi.org/10.1007/s10701-020-00364-2

2. Nisticò G. 2021 *Group Theoretical Derivation of Consistent Massless Particle Theories*. Found Phys 51, 112 (2021). https://doi.org/10.1007/s10701-021-00494-1

LINCOLN
Learning Complex Networks

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

1 Mathematical Models for Semiconductors

1) Analysis of the graphene temperature [1)] and formulation of energy-transport and drift-diffusion models for graphene with quantum corrections [2)].

2 Semiconductor modelling and parabolic partial differential-algebraic equations [3)], development of hydrodynamic models with field-dependent mobility [5)], Index-Aware Model-Order Reduction [6)] and mathematical modelling of real-life processes.

2 Quantum Measurement

1) Fuzzy observables

   We proved [7)] that there is a universal Markov kernel μ^U (to which there corresponds a universal family of fuzzy events) such that every commutative POVM F is the fuzzification of a self-adjoint operator A^F with the fuzzification realized by μ^U. Moreover, we showed that every weak Markov kernel is functionally subordinated to the universal Markov kernel.

2) Quantum-like systems

We provided [9)] a quantum description of angles in the plane providing illustration of covariant integral quantization, linear polarisation of light as a quantum measurement, entanglement, violation of Bell inequalities, spin one-half coherent states.

3 Epidemic Modelling

We provided [10)] a non-linear space time probabilistic model for epidemic spreading based on a density kernel that contains several well known models (SIR, SI, time-continuous stochastic models, time-discrete stochastic models, SIR stochastic model, Fisher–Kolmogorov model) as particular cases.

4 Congresses

[1] Organization of the minisymposium, Mathematical modeling of charge transport in graphene and low dimensional structures, Ecmi 2021, virtually hosted by the Bergische Universität of Wuppertal, April 13-15 2021.
[2] Comunications at the minisymposium “Charge transport in low dimensional structures”, SIMAI 2020-21, Parma, 30 Agosto- 3 Settembre 2021

[3] Organization of the international conference IQSA2020, postoponed to 2022 because of Covid-19 emergency.

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1. M. Coco, G. Mascali, V. Romano, About the definition of the local equilibrium lattice temperature in suspended monolayer graphene. ENTROPY, vol. 23 (2021).
2. V.D. Camiola, G. Mascali, V. Romano, Quantum energy-transport and drift-diffusion models for electron transport in graphene: an approach by the Wigner function, JOURNAL OF COMPUTATIONAL ELECTRONICS, vol. 20, p. 2135-2140 (2021).
3. G. Alí, N. Rotundo, Existence and uniqueness of solution for multidimensional parabolic partial differential-algebraic equations arising in semiconductor modeling, Math Meth Appl Sci. 1-26 (2021). (DOI: 10.1002/mma.7175).
4. G. Alí,, E. Bilotta, F. Chiaravalloti, C. Scuro, F. Valentini, Spatiotemporal Pattern Formation in a Ring of Chua's Oscillators, Regular and Chaotic Dynamics 26(6), pp. 717–731 (2021).
5. G. Alí, F. Lamonaca, C. Scuro, I. Torcicollo, On a one-dimensional hydrodynamic model for semiconductors with field-dependent mobility, Mathematics, 9(17), 2152 (2021).
6. N. Banagaaya, G. Alí, S. Grundel, P. Benner, Index-Aware Model-Order Reduction for a Special Class of Nonlinear Differential-Algebraic Equations, Journal of Dynamics and Differential Equations (2021).
7. R. Beneduci, T. Gentile, Universal Markov Kernel and the Universal Family of Fuzzy Sets (submitted).
8. R. Beneduci, Universal randomization of Quantum Observables, Int. J. Theor. Phys., 60 558-566 (2021)
9. R. Beneduci, E. Frion, J.P. Gazeau, Quantum description of angles in the plane, Acta Polythecnica (2022) (in print).
10. R. Beneduci, P. Pantano, E. Bilotta, Epidemic Modelling: a unifying non-linear probabilistic approach to grasp the space-time behavior, Scientific Reports, 11, Article number: 13860 (2021).

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

A. Papa (Resp.)

1 Flux tubes in pure-gauge SU(3)

We have extended our investigation of the properties of the vacuum of the SU(3) Yang-Mills theory by means of Monte Carlo simulations on a space-time lattice. From the determination of all components of the color fields surrounding a static quark–antiquark pair, we have found the spatial distribution of the magnetic current responsible for the non-perturbative part of the chromoelectric field, which builds up the "flux tube" connecting the quark sources. A paper reporting these results is in preparation.

2 QCD phase diagram from Polyakov loops effective models

We have studied an effective Polyakov loop model at finite baryon density which is free from the sign problem and is therefore amenable of direct Monte Carlo simulations. We have computed various local observables such as energy density, baryon density, quark condensate and described in details the phase diagram of the model. The regions of the first order phase transition and the crossover, as well as the line of the second order phase transition, have been established. We have also computed several correlation functions of the Polyakov loops.

3 Traffic models

We have proposed a model to implement and simulate different traffic-flow conditions in terms of quantum graphs hosting an $(N + 1)$-level dot at each site, which allows us to keep track of the type and of the destination of each vehicle. By implementing proper Lindbladian local dissipators, we have derived the master equations that describe the traffic flow in our system. To show the versatility and the reliability of our technique, we have employed it to model different types of traffic flow (the symmetric three-way roundabout and the three-road intersection). Eventually, we have successfully compared our predictions with results from classical models. A paper presenting these results [arXiv:2104.06289] has been submitted for publication.

References

1. O. Borisenko, V. Chelnokov, E. Mendicelli and A. Papa,
"Dual simulation of a Polyakov loop model at finite baryon density: Phase diagram and local observables,"
Nucl. Phys. B **965** (2021), 115332 [arXiv:2011.08285 [hep-lat]].

QFT@COLLIDERS
Precision calculations for collider physics

A.D. Bolognino (Dott.), M. Fucilla (Dott.), M.M.A. Mohammed (Dott.), A. Papa (Resp.)

1 Semihard processes in perturbative QCD

High-energy reactions falling in the so-called *semi-hard* sector, where the scale hierarchy, $s \gg Q^2 \gg \Lambda^2_{\rm QCD}$ holds (here, s is the squared center-of-mass energy, Q the hard scale given by the process kinematics and $\Lambda_{\rm QCD}$ the QCD mass scale) represent an excellent channel to probe and deepen our knowledge of strong interactions in kinematic ranges so far unexplored.

The study of these processes by fixed-order calculations in perturbative QCD misses the effect of large energy logarithms, entering the perturbative series with a power increasing along with the order, thus compensating the smallness of the strong coupling, α_s. The Balitsky-Fadin-Kuraev-Lipatov (BFKL) approach represents the most powerful tool to resum to all orders, both in the leading (LLA) and the next-to-leading (NLA) approximation, these large-energy logarithmic contributions. Within this approach, we have considered:

- The inclusive hadroproduction of a heavy-flavored jet in association with a light jet. We have built up a hybrid factorization that encodes genuine high-energy effects, provided by a partial NLA BFKL resummation, inside the standard collinear structure of the cross section. We have presented a detailed analysis of different distributions, shaped on LHC kinematics, and differential in rapidity, azimuthal angle and transverse momentum. The hybrid factorization scheme could help to deepen our understanding of heavy-flavor physics in wider kinematic ranges, like the ones accessible at the Electron-Ion Collider (EIC).

- The inclusive emissions of a double Λ_c or of a Λ_c plus a light-flavored jet system, adopting again the hybrid high-energy/collinear factorization, with NLA BFKL resummation. We have provided predictions for rapidity distributions and azimuthal correlations, that can be studied at current and forthcoming LHC configurations.

- The inclusive semi-hard production, in proton-proton collisions, of two bottom-flavored hadrons, as well as of a single bottom-flavored hadron accompanied by a light jet, as novel channels for the manifestation of stabilization effects of the high-energy resummation under next-to-leading-order corrections. We adopted hybrid high-energy and collinear factorization, with NLA BFKL resummation. We have presented results for cross sections and azimuthal correlations differential in rapidity, and have proposed double differential distributions in the transverse momenta of final-state particles as a common basis to investigate the interplay of different kinds of resummation mechanisms.

Within the BFKL approach at the LLA, it is straightforward to introduce the small-x unintegrated gluon density (UGD), which enters the theoretical description of diffractive processes, such as the leptoproduction of the ϕ light vector meson. In particular, we have calculated cross sections for the exclusive diffractive leptoproduction of ρ mesons, $\gamma^* + p \to \rho + p$, within the framework

of high-energy factorization. Cross sections for longitudinally and transversally polarized mesons have been shown. We have employed a wide variety of unintegrated gluon distributions available in the literature and compared to HERA data. The resulting cross sections strongly depend on the choice of unintegrated gluon distribution. We have also presented predictions for the proton target in the kinematics of the Brookhaven EIC.

2 Talks in Year 2021

1. M. Fucilla,
   Heavy flavour at high energies: from open states to quarkonia,
   Workshop Quarkonia As Tools 2021 (March 22-25, 2021, online)
   https://indico.cern.ch/event/983750/

2. M. Fucilla,
   Hybrid high-energy/collinear factorization in a heavy-light dijets system reaction,
   XXVIII International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2021, Stony Brook, NY, April 12-16, online)
   https://indico.bnl.gov/event/9726/

3. M.M.A. Mohammed,
   High-energy resummation in inclusive hadroproduction of Higgs plus jet (poster session),
   XXVIII International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2021, Stony Brook, NY, April 12-16, online)
   https://indico.bnl.gov/event/9726/

4. M. Fucilla,
   Semi-hard reactions at the Forward Facility,
   2nd Forward Physics Facility Meeting (May 27-28, 2021, online)
   https://indico.cern.ch/event/1022352/

5. M.M.A. Mohammed,
   BFKL phenomenology: Resummation of high-energy logs in inclusive processes,
   50th International Symposium on Multiparticle Dynamics (ISMD2021, July 12-16, 2021, online)
   https://indico.cern.ch/event/848680/

6. M. Fucilla,
   Heavy flavored emissions in hybrid collinear/high-energy factorization,
   European Physical Society conference on High-Energy Physics (EPS-HEP2021, July 26-30, online)
   https://indico.desy.de/event/28202/

7. M. Fucilla,
   Hadron structure at small-x via unintegrated gluon denisties,
   19th International Conference on Hadron Spectroscopy and Structure (HADRON2021, Mexico City, July 26-31, 2021, online)
   https://indico.nucleares.unam.mx/event/1541/session/40/contribution/221

8. M. Fucilla,
   Higgs boson production in the high-energy limit of pQCD,
   Particle and Nuclei Internation Conference (PANIC2021, September 5-10, 2021, online)
   https://indico.lip.pt/event/592/

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SFT - Statistical Field Theory and Applications

D. Giuliano (Resp.), L. Lepori (Ass.), A. Nava (Ass.), F. Plastina (Ass.)

1 Lindblad equation approach to interacting electronic one-dimensional systems [1)]

Using the Lindblad equation approach, we derive the range of the parameters of an interacting one-dimensional electronic chain connected to two reservoirs in the large bias limit in which an optimal working point emerges in the nonequilibrium stationary state. In the specific case of the spinless fermionic Hubbard chain, we prove that an optimal working point emerges in the dependence of the stationary current on the coupling between the chain and the reservoirs, both in the interacting and in the noninteracting case and show that it is robust against localized defects of the chain.

2 Interplay between singlet and triplet pairings in multi-band two-dimensional oxide superconductors [2)]

We theoretically study the superconducting properties of multi-band two-dimensional transition metal oxide superconductors. In particular, we focus on the two-dimensional electron gas at the (001) interface between LaAlO3 and SrTiO3 band insulators where the low electron densities and the sizeable spin-orbit couplings affect the superconducting features. We show how the triplet pairings is able to strongly reduce the singlet order parameters and the interplay between the singlet and the triplet pairings affects the dispersion of quasi-particle excitations in the Brillouin zone. Finally, we show how nontrivial topological superconducting states become stable as a function of the charge density, as well as of the magnitude and of the orientation of the applied magnetic field.

3 Tonks-Girardeau Gas in a Lattice [3)]

We developed a method to evaluate exactly the spectral function for a gas of one-dimensional bosons with infinitely strong repulsions valid for any type of external confinement. The single-particle spectral function of a strongly correlated system is an essential ingredient to describe its dynamics and transport properties. Focusing on the case of a lattice confinement, we found that the spectral function displays three main singularity lines. One of them is due uniquely to lattice effects, while the two others correspond to the Lieb- I and Lieb-II modes occurring in a uniform fluid. Differently from the dynamical structure factor, in the spectral function the Lieb-II mode shows a divergence, thus providing a route to probe such mode in experiments with ultracold atoms.

4 Probing Majorana zero modes by measuring transport through an interacting magnetic impurity [4)]

Motivated by recent experiments we consider transport across an interacting magnetic impurity coupled to the Majorana zero mode (MZM) observed at the boundary of a topological superconductor. In the presence of a finite tunneling amplitude we observe hybridization of the MZM with the quantum dot, which is manifested by a half-integer zero-bias conductance measured on the metallic contacts. We show that the MZM signature in the conductance is robust and persists even at large values of the interaction. Notably, the topological regime is characterized by a vanishing Fano factor, F=0, induced by the MZM. We propose an experimental set-up to measure the conductance and the shot-noise in order to detect the topological properties of the superconducting wire and to distinguish the low-energy contribution of a MZM from other possible sources of zero-bias anomaly.

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Time2Quest

A. Sindona (Resp.), P. Riccardi (Ass.), F. Plastina (Ass.),
J. Settino (Ass.), M. Pisarra (Ass.)

1 Research Activity

As specified in its project proposal, the specific initiative Time2Quest aims at exploring highly demanding computational strategies to unravel excited state properties, collective excitations, transport phenomena and other many-body effects in low dimensional systems of uttermost importance for quantum information processing. The researchers from the CS unit, being one of the four nodes of this project, share their expertise in time-dependent density functional theory and out of equilibrium thermodynamics In particular, during the course of 2021, the CS unit has specifically explored the following topics:

(i) **plasmon excitations, dielectric, electromagnetic, and fundamental properties of two-dimensional Dirac nano objetcs.** A self-consistent strategy, based on time-dependent density functional theory, was applied to several nanostructures based on Carbon, Silicon, Germanium and Tin. After having outlined a new possible direction towards the synthesis of silicene, and setting up an ab initio framework to determine the effective fine-structure constant of graphene, the efforts of this research line were focussed on charge-carrier density oscillations in atomically precise graphene nanoribbons, organized in planar array form. In particular, a bulk and an edge quantized oscillations (better known as plasmons) were identified at far infrared to visible energies, and over a broad range of momentum transfers. Further scrutiny is being placed on the possibility to establish a true one-dimensional confinement of the charge carrier density on individual nanoribbons [1]. Another important achievement has been concerned with the detection of virtually massless and massive plasmon modes in germanene sheets synthesized on top on large gap insulators (AlN) and semiconductors (MoS_2), thus establishing novel platforms for photonic and electronic nano-device architectures [2, 3].

(ii) **Electronic properties of novel 2D Materials** A particularly appealing class of 2D materials, known as transition metal dichalcogenides (TMD), were scrutinized. Due to their specific structure, these materials are easily exfoliated down to the single layer and present several phases with different electronic and structural properties. Specifically, the electronic properties of Tantalum Di-Sulphide (TaS2) were taken into account in a joint theoretical and experimental project showing that, using a combination of the two most common phases of this material (1T and 2H), it is possible to induce a new electronic phase in the material itself. Indeed, under controlled growth conditions, when the temperature is lowered down to few degrees Kelvin, the electrons of one of the TMD layers interact to form an ordered array of magnetic moments. These magnetic moments are screened by the conduction electrons of the underlying 2H-TaS2 supporting substrate, with the formation of a coherent state, a 2D Kondo lattice. In this context, an effective Hamiltonian was defined, which includes an impurity band coupled to the conduction bands of the metallic substrate, responsible for the

screening. The subsequent calculations proved that the measured electronic features of the system are compatible with the physics of the Kondo lattice [4]. Additionally, a concurrent real-space and -time imaging of coherences was proved to involve the valence orbitals of perylene-tetra-carboxylic dianhydride molecules, and full control over the population of the involved orbitals was achieved [5]. Finally, the on-surface photo-generation of nona-cene from α-bisdiketone precursors deposited on nano-structured epitaxial graphene grown on Ru(0001) was theoretically modelled and experimentally characterized by low temperature scanning tunneling microscopy and spectroscopy [6].

(iii) **Electron emission from surfaces.** The electron emission in the interaction of singly charged Na^+ and Ne^+ with Al surfaces was measured and modelled by a promotion mechanism involving a transient molecule, formed during the binary collision with an Al target atom. Doubly excited states were observer and caracterized in single scattering events involving neutral Neon projectiles and neon-like Na^+ ions. Measurements performed with Neon projectiles at impact energy up to 10 keV revealed the onset $2s$ excitation via promotion of the 3p sigma molecular orbital [7]- [9].

(iv) **Out of equilibrium thermodynamics.** The single-particle spectral function of a strongly correlated system is an essential ingredient to describe its dynamics and transport properties. A method to evaluate exactly the spectral function for a gas of one-dimensional bosons with infinitely strong repulsions was developed and proved to be valid for any type of external confinement. Focusing on the case of a lattice confinement, the spectral function was found to displays three main singularity lines. One of them is due uniquely to lattice effects, while the two others correspond to the Lieb-I and Lieb-II modes occurring in a uniform fluid [10].

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STAR PROJECT

STAR
Southern Europe Thomson Backscattering Source for Applied Research

S. Donato (Ass.)

1 Computed Tomography applied to geology, entomology, medical physics and material science.

1. Microanalytical study by Wave Dispersion System associated to Electron Probe Micro-Analyzer, Scanning Electron Microscope observation, and X-rays micro-tomographic analyses of samples showing different colors (dark to light green, sometimes with bands of different color intensity) and hues (changing, uniform, no hue). X-ray micro-CT experiments were carried on at the @STAR Lab at the University of Calabria using a conventional microfocus source and a flat panel detector. The SEM observation and microtomographic study revealed the absence of microcrystals and the occurrence of vesicles of different size, shape, and orientation. Lighter green colors are shown by highly vesiculated surfaces, whereas non-vesiculated samples are darker [1)].

2. Combination of different imaging techniques (Synchrotron Radiation X-ray Phase-Contrast micro tomography (SR-PhC micro-CT), histology and scanning electron microscopy (SEM)) to describe the abdominal organs of Pterostichus melas italicus Dejean, a species used as a representative model because of its ecological role as a generalist predator in agroecosystems. The histology was performed to define the tissue organization of digestive and reproductive system. SR-PhC micro-CT and 3D rendering provided more accurate information on shape and size of organs than histological and SEM analyses, respectively [2)].

3. Study for the assessment and compensation of breathing's motion artifacts for in-vivo breast computed tomography scans. The aim of the work was to develop a simple model for the respiratory motion by evaluating real breathing displacements on seven volunteers with optical tracking. Additionally, to evaluate the effect of such modeled motion on reconstructed tomographic images of a breast phantom and a surgical specimen. Lastly, to introduce a correction method to compensate for the resulting artifacts [3)].

4. Multiscale Fourier Transform InfraRed (FTIR) study encompassing 1D FTIR spectroscopy, 2D FTIR imaging and 3D FTIR micro-tomography (FTIR micro-CT) on tannin-furanic rigid foams obtained by varying the synthesis parameters in a controlled way. Starting from a 1D investigation with Attenuated Total Reflection (ATR) FTIR spectroscopy, and then progressing into a 2D view through FTIR FPA imaging, an optimized 3D FTIR-μCT protocols was applied to identify if tannin-polyphenols and furanic moieties of the foam are equally distributed all over or if a segregation at the level of the foam volume exists. The proposed multiscale approach allowed to obtain, for the first time, a 3D chemical representation of tannin-furanic foams and highlight their spatial heterogeneity [4)].

2 Conference participation

Poster presentation at the 22nd International Workshop on Radiation Imaging Detectors (iWoRiD 2021)

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STAR
Beamline simulation and optimisation

E. Tassi (Resp.), A. Olivieri (Ass.)

1 Introduction

The research activity, started in May 2021, aims to upgrade the STAR2 Linac simulation. The main activities are:

1. the development of a new simulation for the detailed study of the electron beam dynamics;
2. the characterisation, optimisation and tune-up of the upgraded beamline.

The simulation has been implemented and carried out using Astra (A Space Charge Tracking Algorithm), a simulation framework that allows to track particles under the influence of electric and magnetic fields along the beamline.

2 Simulations

The first goal of the simulation work has been that of reproducing in detail, with the Astra framework, the electron beam performance results presented in the *Complete Detailed Design Report* of the STAR2 upgrade project, including emittance, energy spread and beam envelope along the three cavities (S-band and C-band), in the dispersion and interaction regions (HE-line) and along the dump dipole.
Together with colleagues of the INFN Milan unit and in order to achieve improved results, we are currently working on replacing the simulated analytical dipole with detailed 3D field maps of the dipole in the dispersion region. The framework Giotto (Genetic Interface for OpTimising Tracking with Optics), a program based on genetic algorithms, will be used in the optimization phase.

COMPUTATION TECHNOLOGY

The ReCaS Cosenza Data Center

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

1 Introduction

The ReCaS Cosenza Data Center (see Figure 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 and software developments

The ReCaS Cosenza Data Center has operated for the year 2021 with very high efficiency and stability. As an example, Figure 2 shows, for the ATLAS virtual organization, a comparison of the performance (quantified in terms of slots of running jobs) of the ReCaS Cosenza Data Center w.r.t. that of other Italian ATLAS Tiers 2 sites for year 2021.

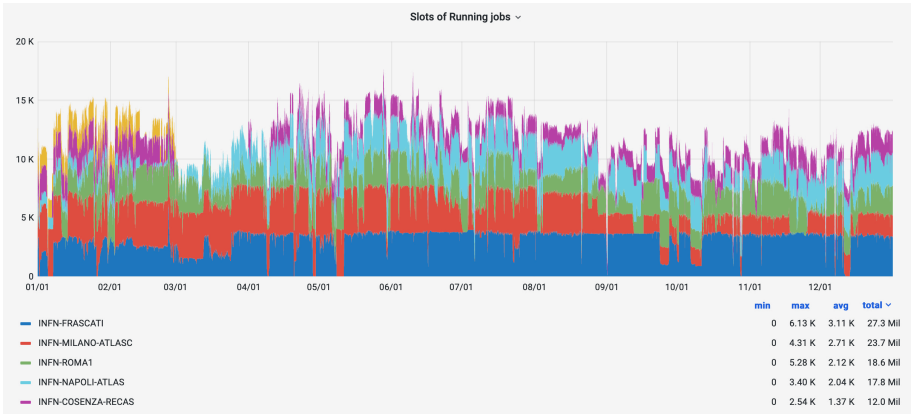

Figure 2: *A comparison of the slots of running jobs in 2021 for the ATLAS Tier2 centers and the ReCaS Cosenza Data Center.*

As far as software development is concerned, in the year 2021, our Local Resource Management System (Torque/Maui) and computing elements (CREAM) were phased-out to adopt HTCondor as a replacement for Torque/Maui and HTCondor-CE in place of CREAM. A number of management tools have been adapted or rewritten in order to integrate the new system with the existing infrastructure. The monitoring tools tied to the old system are being adapted to also work on the new one. The most relevant setup steps have been adopted in conjunction with the other INFN ATLAS grid sites and a public wiki page and a support mailing list have been created.

3 Upgrade

In March 2019 the STAR 2 upgrade project (EU PON programme "Research and Innovations" 2014-2020, code: PIR0_100008) has been funded for a total budget of approximately 17.5 Million Euros and with it the upgrade of the ReCaS Data Center that will be used as the main computing facility for the storage, reconstruction and analysis of the high resolution tomographic images produced by STAR. Due to the covid-19 pandemic, the data center upgrade works have been delayed. They are now planned to start by mid 2022 and should be completed by the end of the same year.

COMMUNICATION AND OUTREACH

RADIOLAB 2021

M. Capua (Resp.), P. Riccardi (Ass.), R. Tucci (Ass.)

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, 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 and with special emphasis on the radon gas. The 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 of interest by them 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 the students and the families and the society connected to them.

From 2020 the second cycle of three years has begun. Five Calabrian schools and two schools in Riobamba in Ecuador (more then 150 students) and more than 520 interviews have been made at the beginning of the activity to citizens to understand the degree of knowledge of the radon risk. The successful experience was presented at:

1. PLS Congress in Catania: Contribuire allo sviluppo professionale dei docenti di fisica nella scuola secondaria, 9-10 February 2021, *Il progetto RadioLab - collaborazione tra ricercatori, insegnanti e studenti delle scuole: l'esempio di RadioLab Calabria*;

2. Workshop PLS-Fisica: Stage e laboratori per la didattica e l'orientamento formativo in fisica, 1-2 July 2021, *Una prospettiva di genere nelle attività dei laboratori di fisica*;

3. Contribution to the international conference Nuclear Education and training, NESTET 2021, *RADIOLAB a High School Italian Project of radon measurements towards the realization of networking and international relations*, 15-17 novembre 2021.

From 2021 RadioLab includes the sub-project called ISORADIOLAB aimed at involving island students in outreach INFN projects. Therefore from November 2021 is involved in the project the Comprehensive Institute Aeolian Islands that includes 155 students of the schools of 6 of the 7 islands.

INTERNATIONAL PHYSICS MASTERCLASSES 2021

M. Capua (Resp.), L. La Rotonda (Ass.), E. Meoni (Ass.), A. Olivieri (Ass.), M. Rossi (Ass.), D. Salvatore (Ass.), E. Tassi (Ass.), C. Petronio (Ass.), R. Tucci (Ass.), F. Stabile (Ass.), A. Tarasio (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 and Basilicata Regions.

In 2021, three events were organized:

- February 11, Internazional Masterclasses-Hands on particle physics - special event for the International Day of Women in Science, 60 students from 11 schools (agenda.infn.it/event/mcg2021).
- March 24, Internazional Masterclasses-Hands on particle physics, 52 students from 10 schools (agenda.infn.it/event/mc2021)

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

In addition and for the first time in Italy (24 March 2021) we organized, toghether with INFN-MI, the Particle Therapy Masterclass. The aim of the Masterclass is to bring students closer to the applications of physics for cancer therapy through conventional radiotherapy and hadrontherapy and to show them the importance of fundamental research and its direct impact on society. This branch of science uses the knowledge acquired on the properties of particles, techniques to accelerate them and the mechanisms of interaction with matter, applying them to human health. In addition to the proposed seminars, in the morning was organized a virtual visit of the CNAO of Pavia. In the afternoon session the students simulated treatment plans to cure prostate, liver or brain cancer using different beams of particles. Finally, a joint videoconference meeting was held at CERN to discuss the results obtained by the students of different countries where the event takes place at the same time.
This first Italian experience was presented at:

1. 107-th SIF 2021 congress, *Particle Therapy International Masterclass: La prima esperienza italiana*, Groppi F., Capua M., Olivieri A., Alborghetti L., Colucci M., Galvez Febles S.S., Tucci R., Sgambelluri N., Cagnetta F.
2. Workshop Nazionale PLS - Stage e laboratori per la didattica e l'orientamento formativo in fisica, 1-2 July 2021, *La Particle Therapy International Masterclass in Italia*, Capua M., Groppi F.

The questionnaires submitted to the students for all three events showed a very high level of approval by the students.

WORLD WIDE DATA DAY 2021

M. Capua (Resp.), C. Petronio (Ass.)

Also in 2021, we participated to the LHC World Wide Data Day, in which students from eround the world analyze LHC data and share results. The project is designed for high schools students that select dimuon events (open data from ATLAS) and calculate the Φ angle of each muon selected in the plane tranverse to the beamline.

THE COSMIC RAYS AS MESSANGERS TO INVESTIGATE THE UNIVERSE

G. Falsetti (Laur.), I. Gnesi (Ass.), D. Liguori (Ass.), A. Mastroberardino (Ass.)
C. Petronio (Ass.), D. Salvatore (Ass.), M. Schioppa (Resp.), P. Turco (Ass.)

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 x 0.80 m. At present 5 MRPCs telescopes are operative in Calabria. In 2020 EEE project becomes a special INFN project under the supervision of Prof. L. Cifarelli. 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 PCTO (Percorsi per le Competenze Trasversali e l'Orientamento) where the students work both into they laboratories and in the "Alte Energie" laboratory of department of physics of UNICAL.

OCRA PROJECT OF INFN-CC3M

M. Schioppa (Resp.)

In the year 2021 the group has participated to the OCRA project of the INFN-CC3M scientific group. The group has built three cosmic rays telescopes with scintillators and measured the absorption power of the atmosphere atoms together the high school students and teachers. In the same year the group has started new project to measure the cosmic ray flux into water at different deeps. The experiment was planed for spring 2020, but the measures to deal with the COVID-19 emergency did not allow the experiment to be carried out. In November the group has coordinated the International Cosmic Day 2021 of the Calabrian schools. They presented the measurement of the cosmic rays flux as a function of the zenith angle, determining the effect of atmosphere as particle absorber.

Premio Asimov 2021

D. Giuliano (Ass.), A. Nava (Ass.), A. Papa (Resp.), M. Rossi (Ass.)

The INFN group of Cosenza has joined since 2018 the "Premio Asimov" initiative (web site: https://www.premio-asimov.it/) and coordinates the related activities in 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, held in videoconference on May 29, 2020. The recording of this event is available in the YouTube channel of Premio Asimov, https://www.youtube.com/c/PremioAsimov.

The edition of 2021 counted overall about 10000 participants from about 200 schools in the Regions Abruzzo, Basilicata, Campania, Emilia Romagna, Lazio, Liguria, Lombardia, Marche, Molise, Piemonte, Puglia, Sardinia, Sicily, Tuscany, Umbria and, of course, Calabria, which contributed with about 230 students from ten different high schools. On May 22, 2021 a videoconference took place, organized by the Physics Department of the University of Calabria and INFN-Cosenza, with the participation of some of the Calabrian students to be rewarded as best reviewers. The recording of this event is available in the YouTube channel of Premio Asimov, https://www.youtube.com/c/PremioAsimov.