PhD Days

PhD DAYS 2025

Report of Contributions

https://agenda.infn.it/e/48498

Contribution ID: **1** Type: **not specified**

CPV in b-quarks from tt̄ events & Performance studies of the RPC detector and L1 Muon Barrel Trigger

Wednesday 8 October 2025 14:20 (20 minutes)

CP violation (CPV) refers to the non-conservation of charge and parity symmetries, leading to differences between particles and antiparticles that can be probed in heavy flavour decays. In particular, semileptonic decays of b-hadrons provide a sensitive environment to search for CPV through charge asymmetry measurements. Using $t\bar{t}$ events collected by the ATLAS detector, where b-hadrons are abundantly produced, charge correlations can be studied between the lepton from the W boson decay and the soft muon from the semileptonic decay of a b-hadron. With the ATLAS analysis tools, relevant kinematic distributions are produced and the corresponding charge asymmetries are extracted, allowing the study of possible CP-violating effects.

The Resistive Plate Chambers (RPCs) provide the muon trigger in the Barrel region of the ATLAS Muon Spectrometer. They consist of about 3700 gas volumes and over the past two years the gas mixture has been modified to reduce the greenhouse impact. Consequently, the impact of the new gas mixture on the muon detection and trigger efficiency has been investigated. In addition, a new software has been developed to estimate the trigger efficiency based on the number of RPC gas volumes reported as off in the Detector Control System.

Presenter: TRUNCALI, Daniele

Contribution ID: **2** Type: **not specified**

Exploring CEvNS with NUCLEUS experiment & latest updates on the Cryogenic Outer Veto (COV)

Wednesday 8 October 2025 14:40 (20 minutes)

Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) is a weak neutral current process where the neutrino interacts with the nucleus as a whole. The CEvNS cross section is several orders of magnitude larger than that of other low-energy neutrino interactions, even though the single outcome of this process is a very small nuclear recoil.
The NUCLEUS experiment employs cryogenic calorimeters featuring gram-scale $CaWO_4$ and Al2O3 detectors with transition-edge sensors; these detectors have demonstrated exceptional energy resolution, detecting nuclear recoils as low as 20 eV, about two orders of magnitude smaller than those detectable by competitor experiments.
The aim of NUCLEUS is to achieve high-precision CEvNS measurements using neutrinos from the Chooz nuclear power plant.
However, the background level at the experimental site, called "Very Near Site", must be kept under control through a complex system of active and passive shielding.
In this talk an overview of the NUCLEUS experiment and an update on the latest developments of the Cryogenic Inner Veto (COV) will be given.

Presenter: GIAMMEI, Marco

Contribution ID: **3** Type: **not specified**

Measurement and modelling of thermal neutron cross sections for neutron transport simulations

Wednesday 8 October 2025 15:40 (20 minutes)

Simulating the thermal neutron cross section of complex systems is a complicated and time-consuming task: in the thermal energy range, neutron cross sections are determined by the chemical and structural properties of materials, and cannot be accurately approximated by summing the contributions of isolated atoms (e.g. free gas model). Moreover, additional properties of materials, such as nanoscale structural features, as well as magnetic properties, can contribute to the complexity of accurate modelling.
For these reasons, neutron transport codes must rely on thermal neutron libraries, which are currently only available for a handful of materials, and primarily developed for fission, fusion, or industrial applications. Therefore, there remains a need for specialized cross sections in multiple fields that rely on neutron transport simulations, such as medical physics, neutron imaging, radiation shielding and radioprotection.
Here, some case studies relevant to medical applications and radioprotection are presented, ranging from complex hydrogen-based molecules, boron neutron capture therapy moderator compounds, to diatomic molecules abundant in air, with the goal of comparing these specialised models to the traditional free-gas approximation, commonly used in neutron transport simulations.

Presenter: SIMONI, Margherita

Contribution ID: **4** Type: **not specified**

Inferring Multi-scale Chaos Using Sparse Information

Wednesday 8 October 2025 16:00 (20 minutes)

Nonlinearities amplify small uncertainties in initial conditions, resulting in strong unpredictability of the dynamics. We investigate optimal strategies to integrate sparse and noisy data into forecasting models to extend the predictability horizon, with applications ranging from intermittent shell models for turbulence to the spatiotemporal complexity of Rayleigh–Bénard convection, while also considering the role of Machine Learning.

Presenter: FOSSELLA, Francesco

Contribution ID: **5** Type: **not specified**

Hadron phenomenology from Lattice QCD

Wednesday 8 October 2025 15:00 (20 minutes)

In the last decade, several advances in theoretical and algorithmic methods, together with the increase of computational resources, have made Lattice QCD a key tool at the precision frontier of Particle Physics, providing accurate and systematically improvable predictions for observables measured with ever-increasing experimental accuracy. We present the results of a first-principles theoretical study of hadronic observables of phenomenological relevance, such as the R–ratio in $e^+e^- \to$ hadrons, the inclusive semileptonic decays of the D_s meson, and the hadronic vacuum polarization contribution to the muon anomalous magnetic moment $g_\mu - 2$. Strongly entangled with these studies, we discuss the development and performance optimization of Lattice QCD codes, which are pivotal for the efficient use of modern pre-exascale and exascale supercomputers.

Presenter: MARGARI, Francesca

Contribution ID: **6** Type: **not specified**

Search of New Physics at LHCb in leptonic and semileptonic decays of neutral B meson

Wednesday 8 October 2025 15:20 (20 minutes)

The semileptonic and leptonic decays of the B_s^0 meson are key processes in the LHCb physics program, offering complementary windows onto the structure of the Standard Model (SM) and possible signs of new physics. The channel $B_s^0 \to D_s^* \mu \nu_\mu$ provides direct sensitivity to hadronic form factors, which encode the strong interaction dynamics governing the transition between heavy and light quarks. Precision measurements of these form factors test lattice QCD calculations, reduce theoretical uncertainties in flavor observables, and improve the modeling of backgrounds in rare decay searches. In parallel, the rare purely leptonic decay $B_s^0 \to \mu^+ \mu^-$ is highly suppressed in the SM and serves as an incisive probe of virtual contributions from physics beyond the SM. LHCb' s high B_s^0 production rates and excellent muon identification capabilities uniquely enable detailed studies of both classes of processes. In this presentation, an overview of the current status of the two analyses will be given, highlighting their relevance for advancing precision flavor physics at the LHC.

Presenter: MANGANELLA, Federico

Contribution ID: **7** Type: **not specified**

Surface Physics Approach to Prebiotic Molecular Aggregation on Mineral Substrates: Focusing on the Earliest Stages

Wednesday 8 October 2025 16:20 (20 minutes)

This project explores the controlled deposition of amino acid molecules onto mineral surfaces relevant to the early Earth environment, under ultra-high vacuum conditions. As an initial step, suitable substrate materials were characterized. Reflectance Anisotropy Spectroscopy (RAS) and X-ray Photoemission Spectroscopy (XPS) were employed to investigate layered systems such as $Ge_2Sb_2Te_5$, as well as TiO_2 and GeAs, which serve as substrates of both physical relevance and scientific interest. Complementary experiments were also carried out on chiral molecules in liquid solution using CD-RAS, providing insights into their optical activity. Furthermore, the project included initial developments in on-surface synthesis techniques, laying the groundwork for future studies on molecular aggregation processes and their correlation with temperature.

Presenter: TOMEI, Ilaria

Contribution ID: **8** Type: **not specified**

Wetting problems with advanced computational techniques

Wednesday 8 October 2025 16:40 (20 minutes)

Wetting is a captivating class of phenomena whose study intertwines physics, chemistry, and engineering.
Macroscopically, a droplet's tendency to wet a solid can be fully described in terms of its surface tension and equilibrium contact angle, that is the angle formed at the interface between the solid, liquid, and gas phases. However, when spreading processes are considered, molecular interactions start playing an important role, making an unambiguous description hard to achieve.
To tackle this problem, we develop a mesoscopic computational method based on the immersed boundary lattice Boltzmann (IBLB) method and validate it against analytical solutions and known experimental results in equilibrium and spreading scenarios.

Presenter: BELLANTONI, Elisa

Contribution ID: **9** Type: **not specified**

Molecular nanostructures for advanced materials

Wednesday 8 October 2025 17:00 (20 minutes)

My projects focus on the study of novel molecular systems by means of low-temperature scanning tunnelling microscopy (STM), operating at 10 K under ultra-high vacuum conditions. In particular, I am focusing on molecules featuring chalcogenazolo-pyridine (CGP) moieties that persistently self-assemble through double chalcogen interactions, giving rise to ordered supramolecular structures on metal surfaces, and on double-decker paracyclophane compounds where their upper aromatic plane is electronically decoupled from the metal substrate, which makes them suitable for hosting and probing guest species. Furthermore, due to the presence of bromine atoms, in the latter compounds, they can undergo on-surface synthesis processes, such as Ullmann coupling, leading to the formation of new covalently bonded structures.

Presenter: CAPORALE, Antonio

Contribution ID: **10** Type: **not specified**

Supercooled First-Order Phase Transitions in Early Universe Cosmology

Wednesday 8 October 2025 17:20 (20 minutes)

Many extensions of the Standard Model predict first-order phase transitions (FOPTs) that may have occurred in the early universe. In particular, theories with classical scale invariance are associated with strong phase transitions capable of producing gravitational-wave signals potentially detectable in future interferometer experiments. Recently, the possibility of primordial black hole production during FOPTs has also been explored. Moreover, the supercooling typical of this class of transitions can give rise to a short period of inflation, after which the universe must be reheated, either through perturbative reheating or preheating. We also find that, during reheating, a significant amount of dark matter can be produced.

Presenter: RESCIGNO, Francesco

Contribution ID: **11** Type: **not specified**

Radiopure crystal scintillators for rare-event searches: my PhD work recognized by the SIF "Ettore Pancini" Prize

Wednesday 8 October 2025 14:00 (20 minutes)

I present the core results of my PhD research - recognized with the SIF "Ettore Pancini" Prize for Nuclear and Subnuclear Physics - on the development and characterization of highly radiopure scintillating crystals for rare-event searches. At the DAMA low-background facilities (LNGS), I conducted calibration campaigns, data taking, and analyses with enriched 106CdWO4 and next-generation Cs2ZrCl6 (and related A2MX6) scintillators to search for double-beta decay modes in 106Cd and 94,96Zr. I will discuss crystal selection and radiopurification; detector performances (energy resolution, long-term stability), and analysis techniques (PSD, time–amplitude analysis) that yielded new and more stringent half-life limits in several decay channels. I will then outline how these methods inform my current work within a national PRIN project and the CUPID and GAIAS collaborations, highlighting ongoing detector R&D, background mitigation, and sensitivity projections toward next-generation searches.

Presenter: LEONCINI, Alice

Contribution ID: **12** Type: **not specified**

Complexity in the spectra of graphs and strings

Wednesday 15 October 2025 14:20 (20 minutes)

Complexity plays a pivotal role across diverse fields, often emerging from spectral data and profoundly shaping system behaviour. As a first instance, we analyse the Fiedler eigenvalue of fiber graphs using the Laplacian Renormalisation Group, showing that its flow cannot be fully controlled by the spectral dimension, reflecting the graph's intrinsic structural richness. Moving from discrete networks to a continuous setting, we then examine one-loop scattering amplitudes in Type II string theories. We provide expressions for amplitudes at arbitrary mass level for a subset of states in the NS-NS sector, together with numerical evaluation of specific cases. Drawing on recent studies, we conjecture that these corrections are effectively captured by random matrix statistics, providing a signal of emergent complex dynamics.

Presenter: GRIMALDI, Lorenzo

Contribution ID: **13** Type: **not specified**

Eulerian and Lagrangian turbulence: closure and control problems

Wednesday 15 October 2025 14:40 (20 minutes)

Turbulence, although ubiquitous in nature and engineering applications, remains one of the most challenging problems in classical physics. It is characterized by chaotic and multiscale interactions, with anomalous scaling laws and intermittency, making its theoretical understanding and practical modeling a challenging task. In this presentation, I will cover our recent efforts in developing efficient methods that are able to capture the level of complexity of turbulent flows, both from an Eulerian and Lagrangian perspectives. I will cover different topics, from machine learning methods for closure of the governing equations, to smart Lagrangian particles that can be used to control and manipulate turbulent flows.

Presenter: FREITAS, André

Contribution ID: **14** Type: **not specified**

Growth and characterization of Chalcogenides-based compounds

Wednesday 15 October 2025 15:00 (20 minutes)

Phase change materials (PCM) are a class of materials mainly based on chalcogenides elements, with sharp differences in electrical and optical properties among crystalline and amorphous phase. These properties are widely exploited in various fields such as neuromorphic computing. Ge-Sb-Te based alloy (GST) is the most widespread compound used for the realization of devices; despite this, low crystallization temperature is a strong limitation for several applications. The effect of Titanium doping on variation of crystallization onset has been investigated for several Ti concentrations. Together with doping, novel Phase Change compounds have been investigated to overcome the aforementioned limitations. In-based PCM resulted in a group of interesting materials, in particular In-Ge-Te is a still unexplored alloy, so a structural characterization has been carried out, with a peculiar focus on the crystallization process.

Presenter: PETRUCCI, Christian

Contribution ID: **15** Type: **not specified**

Exploring complexity with network and computational methods: from statistical validation to applications

Wednesday 15 October 2025 15:20 (20 minutes)

Statistical validation of complex networks through maximum-entropy null models is explored as a robust framework to identify significant structures in large-scale data. These methods are applied to computational social science, including the study of polarization, echo chambers, language complexity, and information diffusion in online discourse. Simulations of social systems with large language models and machine learning illustrate the potential of computational approaches, while also emphasizing the irreducible complexity of social dynamics. Furthermore, extensions of network methods, such as Laplacian renormalization techniques, are investigated to analyze multiscale network behavior, with applications ranging from social dynamics to neural time series. Overall, the research highlights the versatility of network-based methodologies across diverse domains of complexity.

Presenter: CIRULLI, Daniele

Contribution ID: **16** Type: **not specified**

Exploring Corporate Financial Statements with Machine Learning: Sentiment, Structure, and Retrieval

Wednesday 15 October 2025 15:40 (20 minutes)

Corporate financial statements provide a comprehensive summary of a company's annual performance, but they also reflect writing biases, shaped both by the author and by the historical moment in which they are produced. Sentiment analysis can help uncover these biases by classifying the tone of the text on a scale from positive to negative. This is possible through the use of neural networks, ranging from LSTM to more advanced Transformer-based models.
Despite being standardized, financial statements also present structural biases. An information of interest is not always easy to locate–even keyword searches often aren't enough–because these documents include several related topics, making the text inherently complex. The goal of this research is to fine-tune an open-source language model (LM) on a built-from-scratch database of financial documents, in order to build a Retrieval-Augmented Generation (RAG) pipeline. By asking questions (queries) to the model, it's possible to identify specific topics within the documents and generate coherent, context-aware answers.

Presenter: PICANO, Daniele

Contribution ID: **17** Type: **not specified**

Generation and Characterization of Secondary Radiation from Laser Wakefield Acceleration

Wednesday 15 October 2025 17:00 (20 minutes)

Laser Wakefield Acceleration (LWFA) is a promising technique for generating relativistic electron beams and secondary radiation in compact experimental setups, through the interaction of an ultra-short, high-intensity laser pulse with a supersonic gas jet. Beams of X-rays, known as betatron radiation, are generated by the transverse oscillations of electrons in the plasma channel created from the interaction. In addition, THz radiation can be emitted when the electrons leave the plasma–vacuum boundary.
For the EuPRAXIA Advanced Photon Source (EuAPS) project, the first user-dedicated betatron source is under development at INFN-LNF. The facility will deliver photons with 1-10 keV critical energy, operating at 1 Hz under highly non-linear laser–plasma interaction conditions.

Presenter: STOCCHI, Federica

Contribution ID: **18** Type: **not specified**

Cosmological Inflation and Modified Gravity

Wednesday 15 October 2025 16:00 (20 minutes)

Inflation was introduced to address fundamental issues of the classical Hot Big Bang Theory. Moreover, investigations of the Early Universe could require extensions of Einstein's General Relativity in several directions, as generically predicted, for instance, by String Theory. Higher order terms in the curvature can play an important role in this respect, as shown by the Starobinsky model. In this work, we explore a large class of Einstein-Cartan models based on the introduction of non-linear Holst curvature terms in the presence of dynamical torsion. They naturally lead to inflationary models where the inflaton can be identified with a pseudoscalar field driving in a natural way a single-field slow-roll inflationary phase, fully compatible with the current observational evidences. It is also highlighted how these models can provide post-inflationary matter-antimatter asymmetry (baryogenesis) via thermal or non-thermal leptogenesis and how they can be embedded in supersymmetric models.

Presenter: DI BENEDETTO, Carlo

Contribution ID: **19** Type: **not specified**

Advanced Acoustic for Diagnostic Applications to Audiology and Beyond

Wednesday 15 October 2025 16:20 (20 minutes)

Otoacoustic Emissions (OAEs) offer fast, objective, frequency-specific hearing assessment but remain largely limited to newborn screening. Recent advances in acquisition, analysis, and nonlinear modelling have enhanced their diagnostic potential beyond research settings.
Using advanced swept-tone paradigms with and without contralateral stimulation, specifically designed time-frequency filtering algorithms will be applied to DPOAE signals from various population groups, such as neurological patients, who also underwent neurological tests. We will also assess the effects of posture, age (children to adults), ophthalmological conditions, and microgravity (astronauts) on the DPOAE signals. DPOAE components from different cochlear mechanisms will be separated using theoretical modelling predictions to enhance SNR and improve sensitivity and specificity by reducing spectral "fine-structure"interference, strengthening correlations with clinical variables.

Presenter: SHARMA, Yoshita

Contribution ID: **20** Type: **not specified**

Co-sputtering of metal oxides to reduce opto-mechanical losses

Wednesday 15 October 2025 16:40 (20 minutes)

Mechanical and optical thermal noise fundamentally limit the sensitivity of high-precision optomechanical experiments based on stabilized optical cavities, with gravitational-wave detectors being the main drivers of theoretical and experimental progress in this field. The most informative frequency band for gravitational signals lies in the mid-frequency range (a few to hundreds of Hz), where coating thermal noise originating from thermally driven fluctuations in multilayer dielectric coatings becomes a dominant source. Its magnitude is directly linked to internal friction and stress within the coating layers. Advancing this research requires the development of optimized coatings that reduce thermal noise while maintaining excellent optical performance. Potential directions include exploring alternative mixed metal-oxide materials such as TiO_2-SiO_2, TiO_2-GeO_2, Hf_2O_3, and Zr_2O_3. In this proposed project, we are using the magnetron sputtering apparatus to perform the co-sputtering of Metal oxides on the glass substrates by varying the deposition parameters.

Presenter: ALI, Zahid

Contribution ID: **21** Type: **not specified**

Energy deposition in MRI

Wednesday 15 October 2025 17:20 (20 minutes)

The presentation will focus on the progress of my PhD project. Specifically, it will focus on three aspects:
1) the acquisition chain set up to acquire the SAR from the phantom that will be used for the measurements;
2) the choice of material used to construct the anthropomorphic phantom and the definition of its geometry, which was determined based on the MRI acquisitions performed on the experimental subject;
3) the reconstruction of the phantom's filling fluid, which will be exposed to the radiofrequency during future acquisitions.
All three activities were carried out during my current research at the Campus Bio-Medico University of Rome.
Finally, the next steps for completing my PhD work next year will be presented.

Presenter: MARTELLUCCI, Marco

Contribution ID: **22** Type: **not specified**

Active control of Lagrangian particle transport in complex and turbulent flows

Wednesday 15 October 2025 14:00 (20 minutes)

In this presentation, I will provide an overview of the main results of my PhD, which focused on the control and optimization of Lagrangian particle transport in turbulent flows. I will present my work on using optimal control theory and reinforcement learning to minimize the relative separation of fluid particles navigating chaotic environments, enabling efficient pursuit of drifting targets despite turbulent dispersion. These results illustrate the potential of both equation-based and data-driven approaches for controlling particle dynamics in complex flows. In the final part of the talk, I will briefly mention other projects carried out during my PhD, including the control of active swarms and studies of turbulent intermittency, and I will conclude with a short outlook on my current research directions.

Presenter: CALASCIBETTA, Chiara

Contribution ID: **23** Type: **not specified**

Radiopure crystal scintillators for rare-event searches: my PhD work recognized by the SIF ”Ettore Pancini” Prize

I present the core results of my PhD research - recognized with the SIF “Ettore Pancini” Prize for Nuclear and Subnuclear Physics - on the development and characterization of highly radiopure scintillating crystals for rare-event searches. At the DAMA low-background facilities (LNGS), I conducted calibration campaigns, data taking, and analyses with enriched 106CdWO4 and next-generation Cs2ZrCl6 (and related A2MX6) scintillators to search for double-beta decay modes in 106Cd and 94,96Zr. I will discuss crystal selection and radiopurification; detector performances (energy resolution, long-term stability), and analysis techniques (PSD, time–amplitude analysis) that yielded new and more stringent half-life limits in several decay channels. I will then outline how these methods inform my current work within a national PRIN project and the CUPID and GAIAS collaborations, highlighting ongoing detector R&D, background mitigation, and sensitivity projections toward next-generation searches.

Session Classification: Radiopure crystal scintillators for rare-event searches: my PhD work recognized by the SIF ”Ettore Pancini” Prize