HEP-TEC-2025

Tuesday, 21 January 2025 - Wednesday, 22 January 2025

Book of Abstracts

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Author: Borys Grynyov[1]

Co-author: T.B. Hry'nyova [2]

[1] *Director of Institute Scintillation Materials NAS Ukraine, academician NAS Ukraine.*

[2] *LAPP, Лабораторія фізики частинок Аннесі (LAPP/IN2P3/CNRS)*

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THEORY AND EXPERIMENT OF GRAVITON PHYSICS

Author: Tetiana Obikhod[1]

[1] *Institute for Nuclear Research NAS of Ukraine*

In the framework of physics beyond the Standard Model, an experiment is presented to search for a chiral graviton mode. These particles were found in a special type of liquid that behaves in a special way under the influence of a magnetic field. Studying the properties of graviton modes will provide an opportunity to understand quantum gravity.
To study gravitational modes, inelastic scattering of photons is considered, modeled using microscopic theory with Hamiltonians at different filling factors [1]. A common feature of fractional quantum Hall (FQH) fluids is multiple graviton modes (GMs) in different subspaces in one Landau level (LL). The number of observed GMs is dynamical and meaningful for specific interaction Hamiltonians. Each GM can be interpreted as the null spaces of model Hamiltonians within one LL.
Our goal is to present the geometric origin of GM and the hierarchical structure of conformal Hilbert spaces as null spaces of model Hamiltonians. We then introduce K-group theory to identify each set of GM excitations, which leads to a topological explanation of the emergence of multiple GM.
We'll use the following Hamiltonian
$=\sum_1^N \frac{1}{2m}\bar{g}^{ab}\hat{\pi}_{ia}\hat{\pi}_{ib} + \hat{V}_{int}, where \hat{\pi}_{ia} = \hat{p}_{ia} + e\hat{A}_{ia} the dynamical momentum operator of the i-the electron$,$A_i$ is the external vector potential, connected with magnetic field by formula $B = \epsilon^{ab}\partial_a A_{ib}$. V_{int} describes the dynamics only within a single LL, the magnetic length is $l_B = \sqrt{\frac{1}{e}B}$.
The Hilbert space of a single LL, referred to as the lowest LL (LLL), is parametrized by the metric $\bar{g}_{ab}$, which leads to density modes in higher LLs, known as "cyclotron gravitons". The Hilbert spaces like LLL are called conformal Hilbert spaces (CHSs) as they are generated by the conformal operators like the Virasoro algebra, known as the Virasoro constraint in string theory, applied only on the physical states. Such CHSs are built up with quasiparticles. We can use the apparatus of the K-group for calculation of Hilbert space states of charged particles for explanation of the FQHE, which are topological phases of LLLs. Since we are dealing with four types of interaction, it is appropriate to use the apparatus of vector bundles to describe a complex formation of D-brane type. B-field interacting with D-branes can be taken into account through the Dixmier-Douady invariant, which characterizes the bundles and describes the strength of the Neveu-Schwarz B-field interacting with D-branes. D-branes are topological solitons whose charges are described by Grothendieck K-groups. Reduction of twisted K-groups to an exact sequence of the form $0 \to Z \to Z \to Z_n \to 0 leads to the result K_0(S^3, n[H]) = Z_n$. $This group value determines the topological charges of the D6-brane in the presence of the Neveu-Schwarz - field$[2].

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What's Next in Particle Physics? –Experimental Perspective

Author: Maxim Titov[1]

[1] *CEA Saclay, DRF/IRFU/DPhP, France*

Over the last five decades, many outstanding questions in particle physics have been answered, leading to the Standard Model (SM) and its spectacular confirmation with the discovery of the Higgs boson in 2012, which would supply the heart to this theory. Now the hunt is on for a deeper theory of reality. To answer this question, Europe, Japan, the US and China have proposed plans for building new particle colliders focused on studying the Higgs boson. Higgs'legacy will be the experimental particle physics programme of the 21st century. The open questions of today are just as profound as they were a century ago. However, there appears to be many more of them. Recent discoveries of the Higgs boson and Gravitational waves required increasingly sophisticated instrumentation and have created an exceptionally positive environment in society. Thus, we have a "virtuous cycle"which must remain strong and un-broken –laws of nature enable novel detector and accelerator concepts, which in turn lead to a greater physics discoveries and better understanding of our Universe.

Particle physics is now entering a new era. As the scale and the cost of the frontier colliders increases, while the timescale for projects is becoming longer, fewer facilities can be realized. Moreover, several high-energy physics (HEP) laboratories becoming multi-purpose ones. The pursuit of ever-higher energies will surely be one of the future directions of particle physics; the course will depend on whether one can continue to contain the cost of future colliders in the current worldwide environment. We must take a holistic view of particle physics - whether we find Beyond Standard Model physics at the LHC or not - and select the path to follow in a prudent manner, while maintaining HEP accelerator laboratories and expertize in all regions. Our culture and management structure must evolve to confront these challenges.

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ACCELERATOR TECHNOLOGIES IN UKRAINE FOR THE FCC (e+ e-) AND FCC(hh)

Authors: Grigory Kovalenko[None]; Ivan Guk[1]; Petro Gladkikh[None]

[1] *NSC KIPT*

Until 1993, the Kharkiv Institute of Physics and Technology was the largest scientific center in Ukraine where nuclear physics research was conducted using beams of ɣ-quanta, electrons, protons, and other charged particles. The institute had a number of unique accelerator facilities: the largest linear accelerators in Europe, LU-2000 and LU-300, the H-100 storage facility, and a number of lower energy accelerators. A large team of highly qualified specialists in nuclear and accelerator physics was formed at the institute. After 1993, the production of klystrons for our accelerators was eliminated in Russia, and large accelerator facilities were shut down and it was impossible to resume their operation. Experimental work, which is the basis of nuclear physics research, practically stopped, and researchers were forced to transfer their research to other facilities outside Ukraine or retrain. The absence of "live"work primarily led to the outflow of young specialists from this field of research and the aging of personnel.
Currently, there are only four electron accelerators in Ukraine: the 10 MeV LU-10 technological accelerator, the 30 MeV LU-30 accelerator, the LU-40 accelerator at KIPT, which were restored after damage, and the 25 MeV M-30 microtron at the Institute of Electron Physics, National Academy of Sciences of Ukraine, Uzhhorod.
In connection with this, it became necessary to create a new state program for the development of fundamental and applied nuclear physics research using accelerators and electron storage facilities, as well as a multifunctional accelerator complex for its implementation, which were emphasized in 2022 in [1,2].
In 2023, a monograph was published [3], which outlined the concept of the complex. This conceptual project was based on the ideas for the development of accelerator technologies laid down in the European Strategy for Particle Physics - Accelerator R&D Roadmap [4]. The strategy is a roadmap for the development of accelerators in Europe in the next 5-10 years. These accelerator technologies may be used in the future in the implementation of the FCC(hh) project.

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KINR LHCb CERN

Author: Valery Pugatch[1]

[1] *Institute for Nuclear Research, National Academy of Sciences of Ukraine(KINR)*

Celebrating the 70th Anniversary of the CERN KINR Team enjoys the "PAST, PRESENT and FUTURE"horizons of its eclusive data, p scientific life participating at CERN, taking and analyzing construction and upgrade activities of the experimental setups with a clear roadmap to the end of this century!

In this report, we present KINR activity at CERN with emphasis on LHCb Collaboration.
LHCb (KINR since 1995 –21 researchers)

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INVESTIGATION OF EXOTIC STRUCTURES IN THE LIGHT QUARK SECTOR WITH THE BGOOD EXPERIMENT

Author: Mariia Romaniuk[1]

[1] *Institute for Nuclear Research of NAS of Ukraine*

Unconventional baryonic and mesonic states represent a topical issue in contemporary hadron physics. New results from the charm-quark sector indicate the existence of multi-quark objects beyond the quark-antiquark and 3-quark configurations (mesons and baryons) known from particle physics textbooks, which reveal themselves through unexpectedly narrow structures in energy. They are interpreted as configurations of minimal four or five (anti-) quarks, hence termed tetra- and pentaquarks. It's an open question whether such structures are bound through gluon exchange, i.e. color interaction in the sense of the Standard Model of Particle Physics, or merely represent molecule-like bindings of meson-meson or meson-baryon similar to the binding of nucleons in atomic nuclei. To date investigations were mostly focused on the sector of c and b quarks, but in order to understand whether the newly discovered structures represent a general feature of structure formation from the basic building blocks of matter, quarks and gluons, also the light uds-quark sector is now attracting increasing attention.
The BGOOD photoproduction experiment [1] accesses forward meson angles and low momentum exchange kinematics in the uds sector, which may be sensitive to molecular-like hadron structure. $\gamma n \rightarrow K^0\Sigma^0$ differential cross section measured at BGOOD is shown in Fig. 1. The data are in reasonable agreement with the previous data from the A2 collaboration [2] and in the more forward interval shown, are consistent with the predicted peak from the model of Ramos and Oset. This model suggested a dynamically generated $N^*(2030)$ is the origin of a cusp measured in the $K^0\Sigma^+$ channel [3, 4]. The model also predicted constructive interference in $K^0\Sigma^0$ photoproduction resulting in a peak. Observing this experimentally would therefore be direct evidence of a molecular state in the uds sector [5].

Fig. 1. $\gamma n \rightarrow K^0\Sigma^0$ differential cross section for $0.2 < \cos\theta_{KCM} < 0.5$ and two different fitting methods (red triangles and black circles). The blue squares are data from the A2 Collaboration [2]. The predicted total cross section from Ramos and Oset [4] is included at an arbitrary scale. Figure adapted from Ref. [6].

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KINR proposal to "European Strategy for Particle Physics"(ESPP. 3d Update)

Author: Valery Pugatch[1]

[1] *Institute for Nuclear Research, National Academy of Sciences of Ukraine(KINR)*

In this report, we present KINR proposal to "European Strategy for Particle Physics"(ESPP. 3d Update). https://europeanstrategy.cern/ The preliminary version was submitted after discussion held on-line on the 28th October 2024 Meeting of the Ukrainian Researchers"devoted to Contribution to the European Strategy for Particle Physics".

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LUMINOSITY, BEAM AND BACKGROUND CONTROL SYSTEM RMS-R3 in the LHCb EXPERIMENT

Authors: Dmytro Ramazanov[1]; Oleksandr Okhrimenko[1]; Serhii Chernyshenko[2]; Valery Pugatch[3]; Volodymyr Kyva[3]

[1] *(Institute for Nuclear Research, National Academy of Sciences of Ukraine(KINR)*

[2] *INR NAS of Ukraine*

[3] *Institute for Nuclear Research, National Academy of Sciences of Ukraine(KINR)*

The modernized LHCb detector [1] provides a data set for luminosities in proton-proton collisions up to 2 × 1033 cm-2s-1 and at energies up to 13.6 TeV. Monitoring of the luminosity, beam and background control is necessary to ensure the safe operation of the experiment. To meet these needs, the Institute for Nuclear Research of the National Academy of Sciences of Ukraine created the RMS-R3 radiation monitoring system based on metal foil detectors [2] (an original development of the NAS) and the phenomenon of secondary electron emission.
The Radiation Monitoring System for Run3 (RMS-R3) has been operating as the part of the LHCb detector (CERN) since the end of 2021 [3]. The main tasks of RMS-R3 are to control the luminosity region and background, as well as conditions of the experiment. Intelligent design and geometric arrangement of the RMS-R3 modules in the LHCb experiment enable the precise measurement of proton beams collision region or fixed target nucleus positions with impact of the background. At present, only the monitoring of the relative luminosity at the experiment is carried out online by RMS-R3.
In the control structure of the experiment, the RMS-R3 system measures the frequency of collider beam interactions in a completely independent manner and displays this data on the monitoring screen in the LHCb control center. Using absolute calibration with the PLUME system [4], the RMS-R3 provides duplication of the online luminosity measurement, which is critical for continuous luminosity balancing within acceptable limits (±5%), which is implemented at LHCb by a feedback scheme with the LHC control center.
This work discusses the main results of RMS_R3 in the LHCb experiment: from luminosity measurements to the use of the asymmetry method, as well as comparisons with other beam and background systems (PLUME, VELO, etc.).
The work on the development of software for the RMS-R3 system in ECS, the WinCC-based LHCb control system, and in MONET, the LHCb web-based data quality monitoring system, is aimed at providing online monitoring of instantaneous luminosity, changing the position of the interaction region with precision accuracy and distinguishing between experimental conditions, etc. The advantage of these software solutions is the creation of new tools for LHCb operators and the full integration of the RMS-R3 system into the structure of monitoring the experimental conditions.
Acknowledgements
This work has received funding through the EURIZON project, which is funded by the European Union under grant agrement No.871072. Grant #3014.
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BENT CRYSTALS FOR BEAM STEERING IN ACCELERATORS

Author: Igor Kyryllin[1]

[1] *NSC Kharkiv Institute of Physics and Technology*

One of the important problems of accelerator physics is the problem of deflecting the direction of motion of high-energy charged particles. One of the options for solving this problem is to use thin bent crystals, passing through which the particles change their direction of motion. This occurs when the particles enter the crystal at a small angle to one of the main crystallographic axes or planes. In this case, the impact parameter of the particle interaction with neighboring crystal atoms changes slowly and coherent effects appear in the scattering of the particle by these atoms. Due to this coherence, it is possible to achieve deflection of the particle in a given direction through interactions with atomic strings or planes. The bending of the crystal in certain cases significantly increases the deflection angles of particles. In particular, if a particle moves in a bent crystal in the planar channeling mode [1,2], it can be deflected by an angle significantly exceeding the critical angle of planar channeling [3]. In addition to planar channeling, there are two other mechanisms for deflecting charged particles in a bent crystal: volume reflection of particles [4], when particles perform above-barrier motion relative to atomic planes in a bent crystal, and the Greenenko-Shul' ga mechanism [5], in which particles enter the crystal at a small angle to one of the crystal axes and move in above-barrier mode in the field of the crystal atomic strings.
All three mentioned mechanisms for deflecting high-energy charged particles using bent crystals have been successfully confirmed experimentally, including at CERN. In particular, the deflection of protons with energies around 7 TeV using planar channeling in a bent crystal was successfully demonstrated in experiments at the Large Hadron Collider [6,7]. This report analyzes the feasibility of using bent crystals for collimating charged particle beams in accelerators and for extracting part of the beam into separate channels.

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Integrated HydroKinetic Model at Relativistic Heavy Ion Collider Energies

Authors: Musfer Adzhymambetov[1]; Yuri Sinyukov[1]

[1] *Bogolyubov Institute for Theoretical Physics*

One of the objectives of current and future collider experiments in the GeV range, such as the Beam Energy Scan program at the Relativistic Heavy Ion Collider (RHIC BES) and the Compressed Baryonic Matter experiment at the Facility for Antiproton and Ion Research (FAIR CBM), is to study the phase diagram of Quantum Chromodynamics. These experiments aim to detect signals of a phase transition from quark-gluon plasma to hadron-resonance gas in the observables. Recently, we developed an updated version of the integrated hydrokinetic model specifically tailored for GeV-range experiments. In my talk, I will present preliminary results from our simulations of heavy-ion collisions at RHIC BES energies, comparing two different equations of state—one incorporating a phase transition and the other assuming a crossover. Our findings indicate potential signals of a phase transition at the lowest energies of this experimental program.

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Beam and Background Monitoring System for the CBM Experiment at FAIR/GSI.

Author: Valery Pugatch[1]

[1] *Institute for Nuclear Research, National Academy of Sciences of Ukraine(KINR)*

The proposed design and expected functional characteristics of the monitoring system for the future CBM experiment (GSI/FAIR) [1] are presented. This MS-CBM-R1 system will be created at the Institute of Nuclear Research of the National Academy of Sciences of Ukraine based on the physical and technical principles of metal foil detectors (MFD). The main tasks of the system are to monitor the stability and reproducibility of the experimental conditions, including the reflection of the interaction area using the response asymmetry method of its sensors

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Time-dependent CP-violation in rare B_s^0⟶ ϕ(1020) μ^+ μ^- decays at FCC-ee

Authors: Ben Kilminster[1]; Jason Aebischer[2]; Tsz Hong Kwok[1]; Valeriia Lukashenko[1]; Zach Polonsky[None]

[1] *University of Zurich*

[2] *CERN*

Rare decays are widely recognized as an excellent laboratory for testing the Standard Model at high precision and searching for the New Physics phenomena [1]. The flavor-changing neutral currents, like b⟶s l^+ l^- transitions, are of special interest. They are forbidden at the tree level in the Standard Model and, therefore, can only proceed via higher-order diagrams. If experimental deviation from the Standard Model prediction is observed for these decays, it would indicate the presence of new phenomena. The rare decay branching ratio measurements give direct access to the real part of Wilson coefficients. However, such measurements integrate out the complex part, leaving minimal sensitivity to the complex phases of Wilson coefficients. On the contrary, the time-dependent CP-violation is a powerful probe for complex observables because it directly accesses the complex CP-violating phases in the Standard Model and beyond [2]. Combining the power of the time-dependent CP-violation probe and rare decay's sensitivity to the New Physics opens the door to an imaginary part of the Wilson coefficients and potentially New Physics, otherwise barely accessible.
In the Standard Model, the time-dependent CP-violation in the B_s^0⟶ ϕ(1020) μ^+ μ^- decays is zero at the leading order. Therefore, a significant deviation from zero would indicate non-zero

complex phases of Wilson coefficients. In current machines, it is challenging to get a statistically significant measurement of the time-dependent CP-violation in the B_s^0⟶ ϕ(1020) μ^+ μ^- decays. However, the future FCC-ee machine provides a unique opportunity to collect a large QCD-background-free dataset for flavor physics measurements, enabling high-precision time-dependent measurements of the rare decays [3]. Assuming the IDEA detector design, we present expected experimental sensitivity to the branching, untagged time-dependent, and tagged time-dependent measurements of the rare B_s^0⟶ ϕ(1020) μ^+ μ^- decays [4]. We show the expected sensitivity to the time-dependent CP-violating phase and the sensitivity to the real and imaginary parts of the Wilson coefficients.

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Algebraic version of the critical phenomena theory in the vicinity of critical points

Author: Sergiy Omelchenko[1]

[1] *Institute for Nuclear Research NAS of Ukraine, Kyiv, Ukraine*

1) It is proposed the application to critical phenomena of the previously proposed [1] hypothesis of the phase transition-decomposition of the maternal universe, described by the semisimple Clifford algebra (CA) Cl(1,9) [2], to direct sum of CA Cl(1,3) (which corresponds to our Universe) and "universes-algebras" Cl(0,4), Cl(0,6), which have degenerate time degree of freedom into space one. The motivation for constructing such model and various related studies is caused by recent discoveries in astrophysics, especially when using the James Webb Space Telescope (JWST). These discoveries are questioned the Standard Model with the Big Bang theory (BB). In contrast to the BB theory in this dynamical algebraic model (DAM), it is proposed that the BB did not exist at all, but a phase transition from infinite and continuous universe took place.
2) It is considered a paradigm portals reversible energy tunneling between Minkowski space Cl(1,3) and Cl(0,4) - spaces, which are isomorphic in terms of the sum equality of the corresponding signatures. This fact may explain phase transitions and the appearance of fluctuations when the system achieves the vicinity of critical points not statistically, as in standard theories, but in a systematic natural way, using (i) invertible transformations of the metric in critical area and (ii) the law of conservation of energy as basic invariant under decomposition of the maternal space Cl(1,9).
Here we till ignore reversible tunneling into Cl(0,6) spaces which are non-isomorphic to our Universe as unlikely.
3) Examples of model using in comparison with standard theories of critical phenomena are given, in particular, this algebraic model is used to construct a phase diagram that may differ from the usual QCD phase diagram, the causes and consequences of this difference are given.

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INVESTIGATION OF THE INTERNAL STRUCTURE OF THE DEUTERON AGAINST THE BACKGROUND OF TWO-PHOTON EXCHANGE EFFECTS IN ELASTIC ELECTRON-DEUTERON SCATTERING

Author: Yaroslav Krivenko-Emetov[1]

[1] *National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" & Institute for Nuclear Research*

This work aims to investigate the simultaneous influence of two-photon effects in quantum electrodynamics and logarithmic corrections in quantum chromodynamics on certain observable experimental quantities (structure functions A(Q2) and B(Q2) in elastic electron-deuteron scattering). Analyzing these effects broadens our understanding of electron scattering physics, particularly the manifestations of quark-gluon degrees of freedom in the deuteron.

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Spin correlations of leptons and quarks at high energies

Author: Alexander Korchin[1]

[1] *NSC Kharkiv Institute of Physics and Technology, Kharkiv, Ukraine*

Anomalous contributions to magnetic and electric dipole moments of the tau lepton have brought renewed interest in development of new CP violating signatures in tau-pair production at Belle II and the LHC. We discuss spin-correlation formalism for production of polarized tau leptons in electron-positron and photon-photon processes, and in proton-proton collisions. Such studies can give information on physics beyond the Standard Model. In particular, some observables sensitive to anomalous dipole moments of the tau lepton are proposed and calculated in the conditions of e-e+ and pp colliders.

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Studying The Constant Terms Of The Energy Resolution Of The GRAiNITA Electromagnetic Calorimeter

Author: Denys Klekots[1]

Co-authors: A. Boyarintsev [2]; A. M. Dubovik [2]; D. Breton [3]; D. Picard [4]; G. Hull [3]; H. Chanal [4]; I. Boyarintseva [5]; I. Tupitsyna [2]; J. Lefrancois [3]; J. Maalmi [3]; L. Golinka-Bezshyyko [1]; M. Magne [4]; M. Yeresko [4]; M.-H. Schune [3]; O. Bezshyyko [1]; S. Barsuk [3]; S. Monteil [4]; Y. Hou [4]

[1] *Taras Shevchenko National University of Kyiv*

[2] *Institute for Scintillation Materials of the National Academy of Sciences of Ukraine*

[3] *Université Paris-Saclay, CNRS/IN2P3, IJCLab*

[4] *Université Clermont Auvergne, CNRS/IN2P3, LPCA*

[5] *Université Paris-Saclay, CNRS/IN2P3, IJCLab; Institute for Scintillation Materials of the National Academy of Sciences of Ukraine*

The GRAiNITA is a novel type of electromagnetic calorimeter with a detection volume filled with high atomic number scintillator grains of about millimetre in size, interfiled with high-density liquid and wavelength shifting (WLS) optical fibres. The calorimeter is being developed to meet the requirements of future collider experiments.

The energy resolution (R = $\frac{E}{E}$) of the calorimeter can be represented by the following formula

$$R = \sqrt{\left(\frac{A}{\sqrt{E}}\right)^2 + B^2}$$

Where **$\frac{A}{\sqrt{E}}$** is a stochastic term, it is due to fluctuation in shower development and statistics of scintillation photons. Previous studies indicate that the stochastic term of $\frac{1\%}{\sqrt{E\ [GeV]}}$ is at reach for

the GRAiNITA calorimeter. **B** is the constant term, representing contributions that do not depend on the energy of the incoming particle. Previous analysis of constant terms based on the assumption of the scintillation light capturing efficiency indicates that its contribution to energy resolution of about 1 % can be expected for the detection of a shower caused by 25 GeV gamma quants. In this study, we used data on light-capturing efficiency obtained from muon beam test measurements with the GRAiNITA prototype alongside the Geant4 simulation to estimate constant terms.

The results of the study show that the energy resolution for 25 GeV gammas stays under 1 %. Also, the map of the detector sensitivity depending on the position of the hit was obtained and showed that its deviation from the mean value stays under 1 %.

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DYNAMIC OF SELF-INJECTED BUNCHES AT LASER WAKEFIELD ACCELERATION IN AN INHOMOGENEOUS PLASMA

Authors: Denys Bondar[1]; Vasyl Maslov[1]; Ivan Onishchenko[1]

[1] *NSC Kharkiv Institute of Physics and Technology*

At the moment, one of the urgent problems of high-energy physics is research in the field of creating an Advanced Linear International Collider (ALIC). This collider is based on the methods of advanced and novel accelerator (ANA), among which one of the most efficient is laser wakefield acceleration.The aim of this study was to investigate the dynamics and parameters of self-injected bunches depending on the plasma density, taking into account that the plasma is inhomogeneous. Clear advantages of using longitudinally and transversely inhomogeneous plasma were shown. Three profiles were considered. The results of the studies demonstrated that the use of longitudinally inhomogeneous plasma leads to an increase of the stay time of the bunch in the acceleration phase. In the case of transverse inhomogeneity, a waveguide effect is observed relative to the laser pulse. In addition, the parabolic inhomogeneous transverse distribution leads to transverse stabilization of the bunch.

The study is supported by the National Research Foundation of Ukraine under the program "Excellent Science in Ukraine"(project # 2023.03/0182).

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PARTON SHOWERS IN PRODUCTION OF Z BOSONS IN PROTON-PROTON COLLISIONS AT THE LHC

Author: Volodymyr Kotlyar[1]

[1] *National Science Center Kharkov Institute of Physics and Technology*

Production of muon pairs in junction with hadronic jets is studied under conditions of LHC experiments [1-3]. Hard parton processes are simulated with MadGraph5_aMC@NLO [4,5] at the tree level and at Next-to-Leading order (NLO) in perturbative quantum chromodynamics (pQCD). The parton processes have n=0,$\cdots$,4 light quarks or gluons in the final states. The generated parton events are showered with the help of Pythia 8 [6,7]. The MLM and CKKWL methods are applied to avoid double counting in treatment of processes, described by the matrix elements, and parton showers. The events with different multiplicities in the NLO calculations are merged in the framework of FxFx approach.

An area of the scale parameters in matching and merging, in which distributions of jets in the transverse momentum and the differential jet rates are smooth and the double counting is substantially

reduced, is determined. The production of Z boson on the mass shell is considered with this end. While multiparton interactions and hadronization result in additional smearing of structures in the differential distributions due to double counting, the observables are shown to depend significantly on elimination of double counting in inclusion of the parton showers.

The obtained integral cross sections and the distributions of the muon pairs in the transverse momentum are compared with the ATLAS, CMS, and LHCb data [1-3]. Influence of processes beyond the leading order in pQCD on the distributions in the central and forward rapidity regions is discussed on the basis of consistent inclusion of the parton showers.
Results of the current research are of interest to determine sensitivity of the observables on parton distribution functions and for evaluation of background in searches of deviation from the Standard Model predictions.

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K_S^0 AND Λ HADRONS PRODUCTION IN PROTON-PROTON AND PROTON-LEAD COLLISIONS AT 5.02TEV STUDIED WITH THE LHCB DETECTOR

Authors: Oleksandr Okhrimenko[1]; S K[2]; Valery Pugatch[3]

[1] *(Institute for Nuclear Research, National Academy of Sciences of Ukraine(KINR)*

[2] *KINR*

[3] *Institute for Nuclear Research, National Academy of Sciences of Ukraine(KINR)*

Production of strange mesons (KS) and baryons (Λ) have been studied with the LHCb in p-Pb collisions at √s = 5 TeV. Cross sections as well as their ratios (Λ-bar/KS, Λ-bar/Λ) have been measured differentially in transverse momentum between 0.15 and 7.0 GeV/c and rapidity in the ranges 1.5 < y < 4.0 and −5 < y < −2.5. The nuclear modification factors are measured for given transverse momentum and rapidity regions as well. Cross section spectra are compared with theoretical predictions in frame of Hybrid (Hydrodynamics, Coalescence, jett Fragmentation) and Parton-Hadron-String Dynamics (PHDS) models.

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DEVELOPMENT AND OPTIMIZATION OF TUNGSTEN MATRIX COLLIMATORS FOR SPATIALLY FRACTIONATED RADIATION THERAPY

Authors: Dmytro Ramazanov[1]; Igor Anokhin[1]; Valery Pugatch[2]; Oleksii Kovalchuk[1]

[1] *Institute for Nuclear research NAS Ukraine*

[2] *Institute for Nuclear Research, National Academy of Sciences of Ukraine(KINR)*

This study investigates the effectiveness of tungsten matrix collimators for spatially fractionated radiation therapy (SFRT). The research combines experimental studies and Monte Carlo simulations to evaluate the fractionation of gamma-ray and electron beams. The results demonstrate the possibility of achieving high fractionation indicators (PVDR over 10) for irradiation of shallow tumors.

The experiments were conducted using a Varian Clinac iX medical accelerator with 6 MeV gamma-rays. Two types of collimators were tested: brass and lead. Monte Carlo simulations were performed using GEANT4 and CERN Fluka software packages, modeling a 10×10×10 cm plexiglass phantom and a tungsten collimator with a 5×5 matrix of 1 mm diameter holes.
The study examined the effects of collimator thickness and radiation energy on fractionation efficiency. For 25 MeV gamma-rays, the optimal tungsten collimator thickness was found to be 12 cm, achieving a PVDR of about 12 at the phantom entrance. For 18 MeV electrons, a 9 cm thick collimator provided a PVDR of about 20. However, the fractionation effect rapidly diminished with depth for both radiation types.
The role of secondary particles in dose distribution formation was also investigated. For gamma-rays, high-energy secondary electrons significantly contributed to the dose at depth. For electron beams, secondary gamma-rays from bremsstrahlung were less significant compared to primary electrons.
Based on these results, three versions of modular tungsten collimator designs were developed. These collimators consist of separate 3 mm thick plates, allowing flexible adjustment of parameters for different energies and beam types.
The study concludes that while SFRT shows promise for treating surface neoplasms, the rapid decay of the fractionation effect with depth limits its application for deep-seated tumors. The proposed modular collimator design offers flexibility for further research and potential clinical applications in adaptive irradiation systems.
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UNDERSTANDING, MODELING AND IMPLEMENTING THE ANALOGUE RESPONSE OF THE SILICON TRACKING SYSTEM OF THE CBM EXPERIMENT AT GSI/FAIR

Author: Oleksandr Kshyvanskyi[None]

A method for simulating the functioning of analog electronics of detector modules based on double-sided microstrip silicon sensors of the Silicon Tracking System (STS) of the CBM experiment has been developed. The method uses the LTspice analog electronic circuit simulator. It provides the ability to simulate the signal charge and its distribution between the detector components, as well as the frequency response of the STS detector module. The simulation results indicate the suitability of this method for validating the characteristics, optimizing the parameters and improving the operation of the STS modules, and the possibility of using it for monitoring the STS during the operation of the CBM experiment.

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Four types of phase transitions in interacting meson (boson) matter at high temperatures

Authors: Volodymyr Gnatovskyy[1]; Dmitry Anchishkin[1]; Denys Zhuravel[1]

[1] *Bogolyubov Institute for Theoretical Physics of the National Academy of Sciences of Ukraine*

Within the framework of the mean field model, the thermodynamics of the relativistic scalar system of interacting particles and antiparticles in the presence of a Bose-Einstein condensate is investigated. It is assumed that the total isospin (charge) density is conserved. It is shown that the particle-antiparticle boson system reveals four types of phase transitions into the condensate phase. Three types belong to the phase transition of the second order and one to the first order. Along with the standard second-order phase transition with the formation of a Bose condensate only in the temperature range $0 \leq T \leq Tc$, three new ones have appeared: the formation of multiple condensate states, a second-order meta-phase transition without the formation of condensate, and the formation of condensate at finite temperatures through a first-order phase transition.

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TIMEPIX3: MULTI-CHANNEL HYBRID PIXEL DETECTOR

Authors: Dmytro Ramazanov[1]; Oleksii Kovalchuk[1]; Andrii Chaus[None]; Valery Pugatch[2]

[1] *Institute for Nuclear research NAS Ukraine*

[2] *Institute for Nuclear Research, National Academy of Sciences of Ukraine(KINR)*

Timepix3 is a universal integrated circuit suitable for reading out semiconductor and gas-filled detectors. Timepix3 can be used in a wide range of applications, from X-ray imaging to particle trajectory reconstruction. Depending on the application requirements, the user can choose one of three data acquisition modes available in Timepix3. In data transfer mode, information about the arrival time and charge magnitude simultaneously with the coordinates of the active pixel is sent outside the chip for each recorded signal. The chosen architecture allows continuous data readout at a rate of up to 4*107 hits/s/cm2.
Initial measurements performed with a calibration source demonstrate the functionality of the chip and achievement of the stated specifications with pixel positioning accuracy, time resolution and noise characteristics. Power consumption is below 1 W/cm2, and the bandwidth reaches 20 Mrad/s/cm2 at 40 MHz. All output channels operate at a maximum speed of 640 Mbit/s. Timepix 3 will be used for quality control of RMS4 during 2MeV electron beam irradiation tests.

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PLASMA WAKEFIELD ACCELERATION AND FOCUSING

High-efficiency acceleration of charged particle beams in the plasma wakefield accelerator was studied experimentally and by numerical simulation (see [1]-[9]). The most impressive experimental results [1] until now in electron accelerating by a wakefield, excited in a plasma, have been achieved using capillary-generated plasma. Plasma-wakefield acceleration provides high accelerating gradients [1,10], promises compact accelerators of high-brightness and high-energy electron beams. Applications of plasma-wakefield accelerators, in particular, particle colliders (see [11]) and free-electron lasers demand low energy spread beams, their small emittance, high current of accelerated bunches, large transformer ratio and high-efficiency operation. Achievement of these requires plateau formation on both the accelerating field for witness-bunch and the decelerating fields for driver-bunch. As it is known plateau formation is possible by controlled beam loading with careful shaping current profile and beam charge selection. We will demonstrate by numerical simulation by PIC code such optimal beam loading in a linear, weakly nonlinear and blowout electron-driven plasma accelerators. Beams for plasma accelerator are prepared with RF linear accelerator with high beam quality. Problems of acceleration of positron bunches in plasma, focusing and stable transport of electron and positron bunches in plasma (see [12]) are important. In the blowout regime the hose instability can appear [13].