Joint Institute for Nuclear Research

Relativistic Nuclear Physics and Quantum Chromodynamics

Book of Abstracts
of the XXI International Baldin Seminar
on High Energy Physics Problems

Dubna, Russia, September 10-15, 2012

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JOINT INSTITUTE FOR NUCLEAR RESEARCH

XXI INTERNATIONAL BALDIN SEMINAR ON HIGH ENERGY PHYSICS PROBLEMS

RELATIVISTIC NUCLEAR PHYSICS & QUANTUM CHROMODYNAMICS

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Contents

OBSERVATION OF THE E(38)-BOSON

Kh.U. Abraamyan[1,2 *], A.B. Anisimov[1], M.I. Baznat[3], K.K. Gudima[3,*], M.A. Kozhin[1], M.A. Nazarenko[4], S.G. Reznikov[1], and A.S. Sorin[5]

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The first results of the search for the E(38)-boson [1] are presented. The search was conducted in the effective mass spectra of photon pairs produced in the d(2.0 GeV/n) + C, d(3.0 GeV/n) + Cu and p(4.6 GeV) + C reactions. The experimental data was obtained at internal beams of the JINR Nuclotron [2].

This work is supported in part by the RFBR Grant No. 11-02-01538-a.

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COMPARISON OF THE TRIGGERS OF THE ATLAS, ALICE AND CMS EXPERIMENTS AND THE TRIGGER OF THE UA1 EXPERIMENT. ANALYSIS OF PROTON-PROTON AND PROTON-ANTIPROTON INTERACTIONS ON BASIS OF THE MC EVENT GENERATOR PYTHIA

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Novgorod State University

The triggers of the ATLAS, ALICE and CMS experiments for proton-proton collisions and the trigger of the UA1 experiment for proton-antiproton collisions are considered. It is shown that uncertainties which arise from different procedures of event selection are not sufficient to explain the difference of about 20–30% in inclusive spectra between the LHC experiments and the UA1 experiment. The dissimilarity in proton-proton and proton-antiproton interactions in simulation by the MC event generator Pythia is also discussed.

COMPARISON OF THE DATA ON PROTON-PROTON AND PROTON-ANTIPROTON INTERACTIONS AT HIGH ENERGIES ON BASIS OF THE LOW CONSTITUENTS NUMBER MODEL

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The experimental data of the LHC collaborations CMS, ATLAS and ALICE have shown the 20-30% disagreement in inclusive cross sections of proton-proton and proton-antiproton collisions at center-of-mass energy 900 GeV when comparing with results of the UA1 collaboration. The experimentalists explain this difference by uncertainties in event selection of the UA1 collaboration. We argue that the difference in proton-proton and proton-antiproton collisions can not be explained only by these uncertainties. We consider total, elastic and inclusive cross sections of proton-proton and proton-antiproton interactions and analyze the possible principles of difference in these interactions on basis of the Low Constituents Number Model. The consequences of such difference for the MC event generators are discussed. The work is supported by RFBR grant 11-02-01395-a.

NUCLEAR TRANSPARENCY EFFECT IN PROTON AND DEUTERON CARBON INTERACTION WITH CARBON NUCLEI

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Experimental results on nuclear transparency effect in proton and deuteron induced carbon interaction at 4.2 A GeV/c (JINR Dubna) are presented. The emitted particles are divided into two groups depending on their polar angle in the lab. frame using "Half angle" ($\theta_{1/2}$) technique. Particles with emission angle greater (outcone particles) and smaller (incone particles) than $\theta_{1/2}$ are considered separately. The behavior of average multiplicity (<n>), 3 momentum (<p>) and transverse momentum (<p_T>) of the incone and the outcone protons, π^- - and π^+ -mesons are studied separately as a function of the number of identified protons (N_p) in an event. For quantitative description, the results are compared with cascade model. We found several cases the behavior of which could be considered as transparency effect. Analysis of the results shows that the collective behavior of particle-nucleus interaction could be the reason of the observed nuclear transparency effect.

POSSIBLE ORIGIN OF OBSERVED AT INCIDENT PROTONS ENERGY 50 GeV EVENTS $pp \to pp + n\pi$ WITH ANOMALOUS MULTIPLICITY

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Detected in experiment [1] events $pp \to pp + n\pi$ with anomalously high multiplicity of mesons (up to n=36) have no satisfactory explanation. In existing hypothesis [1] such events are regarded as a possible result of central collisions of protons. Alternative possible mechanism is considered here: succesive emission of pairs of π-mesons by incident proton in the time of formation and disappearance of repeated shortlife rotational states, which may arise in peripheral collision with impact parameter $b \approx 2R_0 \approx 1.0(\pm 0.01)\, f$. The model of "black balls"[2], [3] is used, where nucleons are treated as probability distributions of constituent inner events with sharp boundary $b \leq 2R_0$ of inelastic NN-interactions.

In the case of impact parameter $b \leq 2R_0$ of incident proton with energy E_0 and momentum P_0 the rotational state with orbital angular momentum $L_0 = bP_0$ occurs of two-protons system with moment of inertia $I = 2m_p R_0^2$. Large kinetic energy of this state $E_{rot} = L^2/2I \gg E_0$ must be compensated by decrease of potential energy $\Delta U \sim -E_{rot}$. Shifted by energy $\Delta E \sim E_{rot}$ nonequilibrium state may exist only short time $\delta t_{rot} \approx \hbar/\Delta E$, which is less than time of inelastic interaction $\Delta t_{int} \sim \hbar/2cP_0$. Therefore during the time Δt_{int} such noneqilibrium rotational states can appear and disapear $\sim \Delta t_{int}/\delta t_{rot} \gg 1$ times. (In the case of "tangential" collision $b = 2R_0$ with momentum $P_0 = 50\, GeV/c$ initial angular momentum of system is $L_0 \approx 253\, \hbar$ and $\Delta t_{int}/\delta t_{rot} \approx P_0/2mc \sim 25$.) Each occurrence of nonequilibrium interaction ΔU leads to the transfer of longtitudional momentum $\delta P_{p'}$ to proton-target and to the decrease of angular momentum $\delta L_p = 2R_0 \delta P_{p'}$ of incident proton. Proton-target does not contribute to the angular momentum (of motion about its center of gravity), therefore for conservation of total angular momentum (in laboratory coordinate system) simultaneously with momentum transfer $\delta P_{p'}$ incident proton has to emit a meson with such parameter $b_{mes} > 2R_0$ and longtitudional momentum P_{mes}, that its contribution $L_{mes} = b_{mes} P_{mes}$ is equal to the decrease of angular momentum of proton: $\Delta L_p = 2R_0(\delta P_{p'} + P_{mes}) = L_{mes}$. Parity of two-protons state with reduced by $\Delta L_p = L_{mes}$ angular momentum remains during emission of a pair of π-mesons in 0^+ state or σ-meson, which carries even momentum $L_\sigma = b_\sigma P_\sigma$ and further disintegrates into the observed π-mesons. This can be repeated for each appearance of short-lived rotational state. In such events all observed π-mesons may appear in small volume outside nucleons at a distance $b_\pi \sim 2R_0$ from the point of contact of interacted protons.

Only even numbers of observed π-mesons $n_\pi = 2n_\sigma$ are predicted by this mechanism. Simultaneous emission and disintegration of few σ-mesons may explain increasing of neutral pion number fluctuations, which were observed in events with large n_π [4].

System of protons experiences n_σ sudden accelerations in the case of such n_σ mesons emission. Addition of n_σ apmplitudes of bremsstrahlung may explain detected probability of soft photon radiation (with $P_\gamma < 50\, MeV$), which is several times larger in observed events than expected one from other possible mechanisms of reaction with large n_π [4].

In the events, where 36 π-mesons were detected [1] with mean energy 70 MeV in s.c.m., assumed here 18 mesons give contribution $E'_{18\sigma} \approx 7,56\, GeV$ to total energy $\sqrt{s} \approx 9,78\, GeV$.

Only with the value $L_\sigma = 12\,\hbar$ of σ-meson angular momentum $b_\sigma P_\sigma$ such mechanism of mesons production would be consictent. Then a conservation of angular momentum $\Delta L_p = L_\sigma$ and supposition of peripherical collision $b_p \approx 2R_0$ define the decrease of momentum $\Delta P_p = L_\sigma/2R_0 \approx 2.36\,GeV/c$ of incident proton and its momentum $P_p = P_0 - n_\sigma \Delta P_p$ after emission of n_σ mesons. For maximum number $n_\sigma = 18$ final value $P_p \approx 7,3\,GeV/c$ of this momentum may be predicted.

Momentum of meson $P_\sigma = L_\sigma/b_\sigma$ with $L_\sigma = 12\,\hbar$ and transfered to the proton-target longtitudional momentum $\delta P_{p'} = \Delta P_p - P_\sigma$ are depend on parameter b_σ of emission of this meson. In the case of maximum value $b_\sigma^{(max)} = 3R_0 \approx 1.5\,f$ momentum of meson must be $P_\sigma \approx 12\hbar/b_\sigma^{(max)} \approx 1,58\,GeV/c$ and transfered to proton-target momentum must be $\delta P_{p'} \approx 0.78\,GeV/c$. Then after emission of $18\,\sigma$-mesons longtitudional momentum of proton target $P_{p'} \approx 14.22\,GeV/c$. Without taking into account small contributions of transverse momenta approximate estimation is $E_{18\sigma} \approx E_0 - E_p - E_{p'} \approx 29,30\,GeV$ for energy of these 18 mesons, so their mean velocity $v_\sigma \approx 0.97\,c$ is less than velosity of centre mass $v_{s.c.m.} \approx 0.981\,c$, and velocity of final protons system $v_{p+p'} \approx 0.996\,c$ is more than $v_{s.c.m}$. If such or similar difference of velocities in the events with large number of mesons will be detected, this may be explained by considered mechanism.

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LHC BOSON 126 GeV AND TOTAL (N,N) AND (γ,γ) CROSS-SECTIONS

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Assumption is argued that found in LHC boson with $m \approx 126\,GeV/c^2$ may be connected with increase of nucleon-nucleon cross-section $\sigma_{tot}^{(pp)}(\sqrt{s}) \approx (\sqrt{s}/E_0)^{1/5}\sigma_0$ (where $\sigma_0 \approx 40\,mb$ and $E_0 \approx 70(\pm5)\,GeV$) at high energy . This empirical expession and equality $\sigma_{tot}^{(pp)} \approx 5\sigma_{el}^{(pp)}$ may be explained [1] as result of sharp boundary of inelastic interaction in (N,N) collisions (taking into account correct expressions $\sigma_{el}^{(R_0R_0)} = \pi R_0^2$, $\sigma_{inel}^{(R_0R_0)} = 4\pi R_0^2$ for scattering of "black balls" with radius R_0) and as consequence of the size $r_0 \approx \hbar c/2E_0$ of constituent possible events in inner probability distributions of interacted nucleons.

Separation of possible events on inelastic (p,p)scattering with impact parameter $b < 2R_0$ and elastic with $b > 2R_0$ follows from causality and from absence of interference of elastic and inelastic scattering. It is supposed that during collision with impact parameter b inner distributions of protons turn into nonequilibrium with size $b/2$ and until $b > 2R_0 \approx 1.0\,f$ elastically return to equilibrium after interaction, but such "elastic" redefinitions of inner distributions became impossible when $b < 2R_0$. The difference of angular momentum $\delta L = \hbar$ separates the neighbouring elastic and inelastic possible events with $\Delta b \approx \hbar c/\sqrt{s}$.

If sharp boundary of inelastic scattering exists at high energy $\sqrt{s} > 70\,GeV$, then the thickness of border $\Delta b/2 \approx \hbar c/2\sqrt{s}$ of inelastic interaction limits the size of possible events $r < \Delta b/2$ of nonequilibrium distributions. But probability distributions of perturbed events with size $r < r_0$ can became excited even when $R > R_0$ and interaction can became inelastic. So after increasing of protons energy dE the part of coherent elastic events $d'\sigma_{el}^{(p,p)} = -\sigma_{el}^{(p,p)}dr/r = \sigma_{el}^{(p,p)}dE/E$ transforms into "total" (elastic or inelastic): $d\sigma_{tot}^{(p,p)} = d'\sigma_{el}^{(p,p)}$. This equality and "black-balls" expression $\sigma_{el}^{(p,p)} = \sigma_{tot}^{(p,p)}/5$ for coherent elastic cross-section give the equation $d\sigma_{tot}^{(p,p)} = 1/5 \cdot \sigma_{tot}^{(p,p)}dE/E$. Solution of this equation $\sigma_{tot}^{(p,p)}(E) = (E/E_0)^{1/5}\sigma_0$ (with parameter $E_0 \approx 70\,GeV$ and $\sigma_0 = 5\pi R_0^2$) describes total cross-section to energy $\sqrt{s} \sim 30\,TeV$. It explains, why parameter $r_0 = \hbar c/2E_0 \approx 0,0014\,f$ in empirical dependence of $\sigma_{tot}^{(pp)}(\sqrt{s})$ can be interpreted as the size of possible virtual events, which may be turn into real particles with mass $\sim 2E_0/c^2$ during (pp) interaction.

For (γ,γ) scattering the same expressions $\sigma_{el}^{(\gamma\gamma)} = \pi R_\gamma^2$, $\sigma_{inel}^{(\gamma\gamma)} = 4\pi R_\gamma^2$ for collision of identical particles are assumed to be valid. Experimental value $\sigma_{tot}^{(\gamma\gamma)} \approx (3,5 \pm 0,5\,)10^{-4}mb$ at energy $\sqrt{s} \sim 2 \div 70\,GeV$ gives the radius of inelastic interaction $R_\gamma \approx (1,5 \pm 0,1)10^{-3}f$. Equality $R_\gamma \approx r_0$ may mean that nonequilibrium distribution of photon coincides with one possible virtual event with the same size r_0 as constituent events in nucleons. If nucleon and photon with $m_\gamma = 0$ are formed by the same events, then it is improbable that these events may be associated with "Higgs" boson. The LHC peak 126 GeV can be treated as possible observation of such events, but then it probably is not Higgs boson.

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SELF-SIMILARITY OF HIGH-$\mathrm{P_T}$ HADRON PRODUCTION IN pA COLLISIONS

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New data on inclusive transverse momentum spectra of charged hadrons produced in pA collisions at U70 are analyzed in the framework of the z-scaling approach. The scaling function $\psi(z)$ is expressed via the invariant cross section $Ed^3\sigma/dp^3$ and the average multiplicity density $dN_{ch}/d\eta(\sqrt{s},\eta)$ of charged particles. Results of analysis are compared with data obtained by J.Cronin, R.Sulyaev and G.Leksin groups. The concept of z-scaling is discussed. The A-dependence of scaling function $\psi(z)$ at high z is verified. Self-similarity of hadron production in pA collisions over a wide kinuimatical range is confirmed.

RADIOACTIVE NUCLEI STOPPED IN NUCLEAR TRACK EMULSION

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In the energy range of nuclei several MeV per nucleon, there is a possibility of implantation of radioactive nuclei into detector material. Of course, in this approach daughter nuclei are investigated rather than the nuclei themselves. In this respect it is worth mentioning the known, although somewhat forgotten, possibilities of NTE for the detection of slow radioactive nuclei. More than half a century ago, "hammer" tracks from the decay of ^{8}Be nuclei through the first excited state 2^+ of about 2.0 MeV were observed in NTE. They occurred in the α decays of stopped ^{8}Li and ^{8}B fragments, which in turn were produced by high-energy particles. Another example is the first observation of the ^{9}C nucleus from the decay $2\alpha + p$. When used with sufficiently pure secondary beams, NTE appears to be an effective means for a systematic study of the decay of light nuclei with an excess of both neutrons and protons. In NTE the directions and ranges of the beam nuclei and slow products of their decay can be measured, which provides a basis for α spectrometry. A question of major importance is to supplement the 3α spectroscopy of ^{12}N and ^{12}B decays with data on 3α angular correlations.

In March 2012 NTE was exposed at the Flerov Laboratory of Nuclear Reactions (JINR) at the ACCULINNA spectrometer . The beam in use was enriched by 7 A MeV ^{8}He nuclei. A 107 μm thick NTE pellicle was oriented at a 10° angle during irradiation, which provided approximately a five-fold effective thickness increase. For ten minutes of irradiation, statistics of about two thousand of such decays was obtained. It is pleasant to note that the used NTE have been recently reproduced by the enterprises "Slavich" (Pereslavl-Zalessky, Russia).

Λ and $\Sigma^{+}(1385)$ HYPERONS RECONSTRUCTION BY CBM-ROOT

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The CBM experiment at FAIR will investigate the QCD phase diagram at high baryon densities[1]. Energy densities above GeV/fm^3 appear at $E_{lab} > 5$A GeV and exist during the time interval less than 5 fm/c. Baryon densities above $10n_0$(n_0- normal baryon density) can be reached at E_{lab} >10 GeV A in heavy A+A collisions[2].One of the signatures of this new state is the enhanced production of strange particles, therefore hyperon reconstruction is essential for the understanding of the heavy ion collision dynamics. The experimental Λ/π^+ ratio in the pC reaction is approximately two times larger than this ratio in pp reactions at the same energy [3]. Reconstruction of $\Sigma^{*\pm}$ (1385) hyperons for p+p, p+nucleus, nucleus-nucleus collisions at SIS energies[4],[5] are a good experience for a next step study of exotica and et. al as in [1],[3] reports. The high statistic study of multi strange hyperons and exotica production FAIR, SIS energies will be one of important task for CBM project in proton-nucleus and nucleus-nucleus collisions [1],[3].

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APPLICATION OF HIGH QUALITY ANTIPROTON BEAM WITH MOMENTUM RANGING FROM 1 TO 15 GeV/c TO STUDY CHARMONIUM AND EXOTICS OVER $D\overline{D}$ -THRESHOLD

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The study of strong interactions and hadronic matter in the process of antiproton-proton annihilation seems to be a challenge nowadays. The research of charmonium, charmed hybrids spectra and their main characteristics (mass, width and branch ratios) in experiments using antiproton beam with momentum ranging from 1 GeV/c to 15 GeV/c, are promising to understand the dynamics of quark interactions at small distances. Charmonium spectroscopy is a good testing tool for the theories of strong interactions: QCD in both perturbative and non-perturbative regimes, LQCD and QCD inspired phenomenological potential models.

Nowadays the scalar $^1P_1$, $^1D_2$ and vector ^3P_J, ^3D_J, - charmonium states and higher laying scalar $^1S_0$ and vector $^3S_1$ – charmonium states are poorly investigated. The domain over $D\overline{D}$ - threshold of 3.73 GeV/c^2 is badly studied. According to the contemporary quark models (LQCD, flux tube model), namely in this domain, the existence of charmed hybrids with exotic ($J^{PC} = 0^{+-}, 1^{-+}, 2^{+-}$) as with non-exotic ($J^{PC}=0^{-+}, 1^{+-}, 2^{-+}, 1^{++}, 1^{--}$) quantum numbers is expected.

The elaborate analysis of charmonium spectrum was carried out, and the attempts to interpret a great quantity of experimental data over $D\overline{D}$ - pair were considered. The decays into $D\overline{D}$ pair, into light mesons and decays with J/Ψ or Ψ' in the final state were considered. Using the combined approach based on the quarkonium potential model and confinement model on a three-dimensional sphere embedded into the four-dimensional Euclidian space, new charmonium states in the mass region over $D\overline{D}$ -threshold equal to 3.73 GeV/c are expected to exist. But much more data on different decay modes (decay channels) are needed for deeper analysis. These data can be derived directly from PANDA experiment with its high quality antiproton beam. The advantage of antiproton beam consists in intensive production of particle-antiparticle pairs which is observed in antiproton-proton annihilation. This fact allows one to carry out spectroscopic research with good statistics and high accuracy. Hence, there is a possibility of measuring the masses, widths and branch ratios of different charmonium states with high accuracy.

The elaborated analysis of spectrum of charmed hybrids with exotic and non-exotic quantum numbers in the mass region mainly over $D\overline{D}$ -threshold is given. Different decay modes of charmed hybrids such as decays into charmonium and light mesons in the final state and decays into $D\overline{D}^*$ -pair (*S*-wave plus *P*-wave mesons) were, in particular, considered. These modes possess small widths and significant branch fractions. This fact facilitates their experimental detection. Using the combined approach based on the quarkonium potential model and confinement model on a three-dimensional sphere embedded into the four-dimensional Euclidian space, the spectrum of lowest-laying charmonium hybrids over $D\overline{D}$ -threshold was calculated. The necessity of further study of charmonium hybrids and their main characteristics (mass, width, branch ratios) in PANDA experiment was demonstrated.

Especial attention is given to the new states with the hidden charm discovered recently (*XYZ*-particles). The experimental data from different collaborations Belle, BaBar, CLEO, CDF were carefully studied. Most of these states were observed over $D\overline{D}$ - threshold in one definite channel. New particles were produced from *B*-meson decays and in electron-positron or two-photon collisions. Their interpretation is far from been obvious nowadays. Therefore many recently discovered states above the $D\overline{D}$ - threshold expect their verification and explanation. Some of these states can be interpreted as higher laying radial excited states of charmonium. This treatment seems to be perspective and needs to be carefully verified in the future PANDA experiment at FAIR.

ON RESULTS OF Y-89 IRRADIATION WITH DEUTERON BEAM ON QUINTA-ASSEMBLY "E+T - RAW" USING NUCLOTRON (JINR DUBNA)

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Collaboration **"E&T - RAW"**

Experimental values of high energy neutron flux in three energy ranges (11,5-20.8, 20,8-32.7, 32,7-100 MeV (Fig.1) and spatial distributions of ^{88}Y, ^{87}Y, ^{86}Y and ^{85}Y isotope production are presented for a QUINTA assembly. Deuteron beam energy range was from 1.0 to 6.0 GeV.

Monte Carlo simulation using MCNPX 2.6 code of the neutron flux density is roughly in agreement with the obtained experimental data.

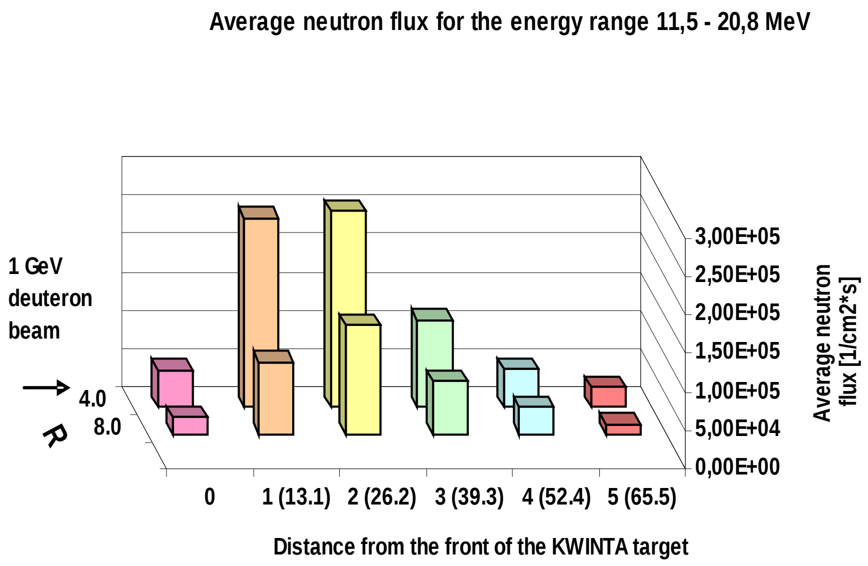

Fig. 1 Spatial average neutron flux distribution in the QUINTA (Kwinta) assembly for the neutron energy range (11.5 – 20.8) MeV for the deuteron beam of 1.0 GeV as the illustrative example.

ON THE CONTINUUM LIMIT OF LANDAU GAUGE GLUON AND GHOST PROPAGATORS IN SU(2) LATTICE GAUGE GLUODYNAMICS

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We continue the systematic computation of gluon and ghost propagators in the SU(2) gluodynamics within the Landau gauge using a sequence of increasing lattice sizes L^4 up to $L = 112$ with corresponding β-values chosen to keep the linear physical size $a(\beta)L \simeq 10$ fm fixed. To minimize the Landau gauge functional we employ the simulated annealing method combined with subsequent overrelaxation. Renormalizing the propagators at momentum $\mu = 2.2 GeV$ we see quite strong lattice artifacts for the gluon propagator within the momentum region $q < 1.0 Gev$. At fixed momenta we provide extrapolations to the continuum limit. We also discuss the continuum limit for the running coupling.

TIMELIKE STRUCTURE FUNCTIONS AND HADRON MULTIPLICITIES

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We present a new approach in considering and including both the perturbative and nonperturbative contributions to the gluon and quark multiplicities evolutions. We report on our progresses in solving a still open puzzle of QCD. The new method is motivated by recent developments in timelike small-x resummation which will also be shown. Global analysis to fit the available data are also presented.

EFFECTS OF THE FINAL-STATE INTERACTION FOR THE EXCLUSIVE DEUTERON ELECTRODISINTEGRATION

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The electrodisintegration of the deuteron is considered within a relativistic model of nucleon-nucleon interaction based on the Bethe-Salpeter approach with a separable interaction kernel. The exclusive cross section is calculated within the impulse approximation under various kinematic conditions. Final state interactions between the outgoing nucleons are taken into account. The comparison of nonrelativistic and relativistic calculations is presented. Partial-wave states of the neutron-proton pair with total angular momentum $J = 0, 1$ are considered [1]. The effects of the inelasticities in the elastic nucleon-nucleon scattering are also investigated.

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MATHEMATIAL MODEL OF DNA LESIONS

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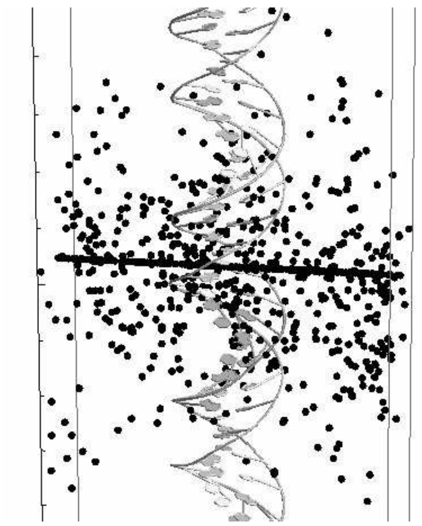
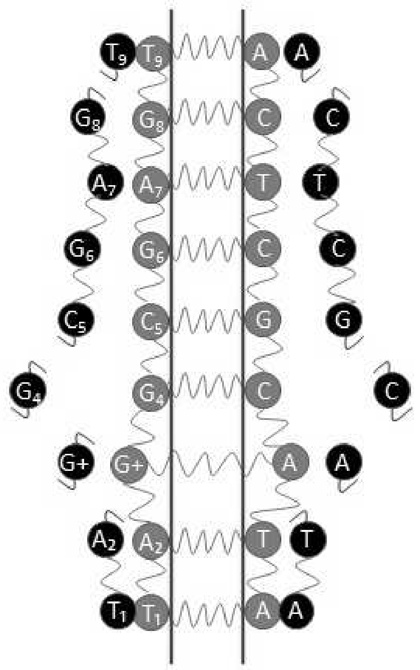
It is well known that ionizing radiation is a mutagen, i.e. ionizing radiation leads to mutations in the deoxyribonucleic acids molecule. The latter may be the cause of various genetic diseases. In this paper the process of DNA molecule ionization was modeled. The ionization radiation was created by pass of alpha particle through matter. Sequence of DNA bases with ionized sites was chosen and the migration of charge was modeled on the basis of quasi-classical double stranded model. This migration resulted in mechanical damage of molecules, in particular the double stranded breaks. These breaks may lead to mutation. Thus, in the paper following process was modelled: alpha particles passing trough matter resulted in conditions for possible mutation.



a)



b)

Figure 1: Graphs of calculations: a) - alpha particles pass around the sequence of the DNA molecule, the DNA spiral represented by a system of nucleotides, and the dots indicate locations of ionization,b) - schematic drawing damage of the DNA chain molecule, bases (gray - in the equilibrium position, black - after the migration of the charge) are shown by circles, bonds between bases are shown by wavy lines (destroyed bonds - tails) around the equilibrium position drawn vertical lines.

LOBACHEVSKY GEOMETRY TRUE SENSE AND "LOBACHEVSKY GENERAL EDUCATION" URGENCY IN HIGH ENERGY PHYSICS

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"Lobachevsky geometry true sense ...", about which Henry Poincaré wrote century earlier [1], consists in that it is an ***internal*** [2] (i.e. **natural**) geometry of the known Lobachevsky velocity space (LVS) which is a base for phase space (PS) of high energy physics (HEP). As the ***internal*** geometry it conserves ***all symmetries*** of particles' mutual transformations, as well known so as unknown ones being searched else. The PS pseudo-Euclidean representation used commonly in HEP breaks contrarily **all symmetries** beside the simplest ones. That is why an extraction physically meaningful information from especially valuable multiparticle data without usage of **all LVS symmetries** in HEP (the most expensive fundamental science) hardly exceeds 3-5%. With (technically caused) incompleteness of these data it doesn't permit to reconstruct statistically in LVS **all evolution footprints** of particles in their interactions. The lust is a ***unique*** possible way for "exploring complexity" and interaction law of particles (according to Ilya Prigogine [3]). That is why now sharper than semicentury ago [4] stands in HEP a large ***Informational–educational problem***. It consist of "non-Euclidean information" scientific community about Lobachevsky geometry as the theory of HEP $\mathcal{L}$-invariants – ***true physical quantities*** and "Lobachevsky general education", i.e. mass teaching HEP physicists in domains: Lobachevsky $\mathcal{L}$-group of motions and symmetries in the Lobachevsky velocity space (LVS) L_3, the ***internal*** Lobachevsky–Euclidean geometry $L_3 \bigotimes m$ of HEP experimental results, LVS method and Lobachevsky invariant (factually **absolute**) multidimensional statistic in L_3. The necessity, problems and different aspects of this general education as scientific–educational part of the Project *"Lobachevsky velocity space in high energy physics"* (***LoVeHEP***) was told by me at four MCE (Mathematics. Computer. Education) International conferences (2004–2012) and at many ISHEPP seminars in Dubna [5]. The aim of this Project is the mass usage of Lobachevsky geometry as the HEP physicists' main working tool for magnification of HEP informational output by 1–1.5 degree which would help to justify all HEP multimilliard $$ cost.

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ADIABATIC CHEMICAL FREEZE-OUT AND WIDE RESONANCE MODIFICATION IN A THERMAL MEDIA

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The hadron resonance gas model [1] is a reliable theoretical tool to extract information about the chemical freeze-out (FO) stage of the relativistic heavy ion collisions. However, the question about the reliable chemical FO criterion has a long history [1, 2]. Very recently this question was thoroughly investigated again [2], using the most sophisticated version of the hadron resonance gas model. Similarly to [1] it was found that none of the formerly suggested chemical FO criteria is robust, if the realistic particle table with the hadron masses up to 2.6 GeV is used. However, in [2] the criterion of the adiabatic chemical FO was suggested. In [2] it was also shown that despite an essential difference with the model of [1] the same conclusion on the constant entropy per particle at chemical FO is reproduced by the chemical FO parameters found in [1]. Thus, it turns out that the criterion of the constant entropy per particle at chemical FO is, indeed, the reliable one.

Despite the long history of this question there was no a single try to understand what is the physical reason behind any of the chemical FO criterion. Therefore we developed a simple model equation of state which not only well describes the chemical FO thermodynamic parameters and reproduces the constant value of the entropy per particle at the chemical FO, but which allows us to elucidate the real mass spectra of mesons and baryons that generate such a criterion. Our analysis demonstrates that the real mass spectrum of hadrons is very much different from the Hagedorn mass spectrum which is traditionally expected to emerge already for hadrons with masses above 1.2 GeV [3]. We argue that the real mass spectrum of hadrons is not an exponential, but a power-like and the reason for such a behavior is in the existence of many wide resonances. The main point is that that the presence of thermal media essentially modifies the resonance mass distribution in case of large width and leads to *the resonance sharpening near the threshold.* The related effect of *wide resonance enhancement* compared to their treatment as stable particles with the average resonance mass is also discussed. Both effects are demonstrated in Fig. 2. Based on these findings we suggest that the quark-gluon bags maybe observed at the NICA energies as the narrow resonances with mass between 2.5 and 4 GeV which are absent in the tables of elementary particle properties.

Contacting the non-relativistic Boltzmann distribution in resonance energy $\phi(m,T) \simeq \left[\frac{m\,T}{2\,\pi\,\hbar^2}\right]^{\frac{3}{2}} \exp\left[-\frac{m}{T}\right]$ with the cut Gaussian distribution $\Theta\left(m - M_k^{Th}\right)\,\exp\left[-\frac{(m_k-m)^2}{2\,\sigma_k^2}\right]$ over the resonance mass m one can easily see that the maximum of the resulting mass distribution is located at $m = \tilde{m}_k \equiv m_k - \frac{\sigma_k^2}{T}$ for k-th resonance. In addition, the resonance degeneracy factor g_k is changed to an effective value $\tilde{g}_k = g_k \exp\left[\frac{\sigma_k^2}{2\,T^2}\right]$. Here m_k denotes the mean mass of the resonance k-th in a vacuum, while its Gaussian width in a vacuum is σ_k (note that the true width of such a resonance is $\Gamma_k = Q\,\sigma_k$ with $Q \equiv 2\sqrt{2\,\ln 2} \approx 2.355$).

A simple analysis shows that the effect of resonance sharpening is strongest, if the threshold mass is larger than the mean effective resonance mass $\tilde{m}_k$, i.e. for $M_k^{Th} \geq \tilde{m}_k$ or for temperatures T below T_k^+. Using the standard definition of the width, one can derive the temperature dependent resonance effective width near the threshold as

$$\Gamma_k^N(T) \simeq \frac{T\,T_k^+}{T_k^+ - T}\ln(2)\,, \quad \text{with} \quad T_k^+ \equiv \frac{\sigma_k^2}{m_k - M_k^{Th}}\,, \tag{1}$$

which very well reproduces the effective width of σ-meson listed in the caption of Fig. 2. The estimate (1) justifies the usage of σ-meson and the field-theoretical models based on the well known σ-model for temperatures well below $T_\sigma^+ \simeq 92$ MeV. Of course, the present approach which is developed for the chemical FO stage, when the inelastic reactions except for resonance decays are ceased to exist, cannot be applied for earlier stages of heavy ion collisions. However, here we would like to stress that an inclusion of the large width of σ-meson in the field-theoretical models of the strongly interacting matter equation of state is very necessary.

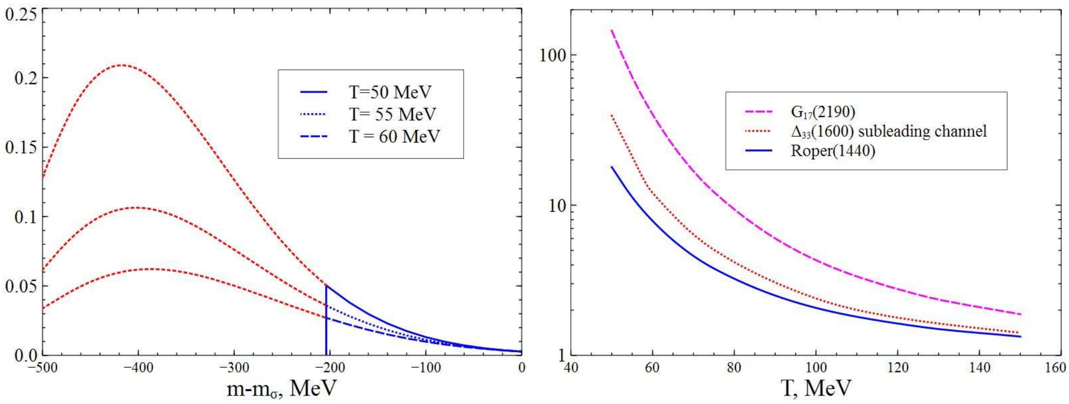

Figure 2: The effects of wide resonance properties modification in a thermal media. The effect of wide resonance sharpening near the threshold is shown for different temperatures in the left panel. The resulting mass distribution (in units of 1/MeV) for σ-meson with the mass $m_\sigma = 484$ MeV, the width $\Gamma_\sigma = 510$ MeV [5] and $M_\sigma^{Th} = 2\,m_\pi \simeq 280$ MeV is obtained after contraction of the original meson mass attenuation (Gaussian) with the Boltzmann distribution integrated over the particle momentum. The short dashed curves below the 2 pion threshold (vertical line) show the mass attenuation for different temperatures. The σ-meson effective width above the threshold has the values: $\Gamma_\sigma^{eff}(T = 50\,\text{MeV}) \simeq 62.5$ MeV, $\Gamma_\sigma^{eff}(T = 55\,\text{MeV}) \simeq 71.5$ MeV and $\Gamma_\sigma^{eff}(T = 60\,\text{MeV}) \simeq 82.5$ MeV. **Right panel** shows the temperature dependence of the resonance enhancement factor $\mathcal{R}_k$ (see text). For wide resonances the effect of enhancement can be huge.

From the right panel of Fig. 2 one can see that the enhancement of the resonance particle density $\rho_k(T, \sigma_k)$, i.e. $\mathcal{R}_k = \rho_k(T, \sigma_k)/\rho_k(T, \sigma_k \to 0)$, can be, indeed, huge for wide ($\Gamma \geq 450$ MeV) and medium wide ($\Gamma \simeq 300 - 400$ MeV) resonances. This effect naturally explains the strong temperature dependence of hadronic pressure at chemical FO, which in its turn generates the power-like mass spectrum of hadrons mentioned above.

The first important conclusion from the analysis above is that there is no sense to discuss the mass spectrum of hadronic resonances, empirical or Hagedorn, without a treatment of their width. Furthermore, the same is true for the quark gluon (QG) bags which, according to the finite width model [4], are heavy and wide resonances with the mass M_B larger than $M_0 \simeq 2.5$ GeV and the mean width of the form $\Gamma_B \simeq \Gamma_0 \left[\frac{M_B}{M_0}\right]^{\frac{1}{2}}$, where $\Gamma_0 \in [400; 600]$ MeV. Also there are two interesting features of QG bags which are related to the above treatment. Thus, for the QG bags one can directly find from (1) the following value of the temperature T_B^+

$$T_B^+ \simeq \frac{\Gamma_0^2}{Q^2 M_0 (1-\xi_B)} \simeq \frac{1}{(1-\xi_B)} \cdot \begin{cases} 11.5 \text{ MeV}, & \text{if } \Gamma_0 \simeq 400 \text{ MeV}, \\ 26 \text{ MeV}, & \text{if } \Gamma_0 \simeq 600 \text{ MeV}, \end{cases} \tag{2}$$

where $\xi_B \equiv \frac{M_B^{Th}}{M_B}$ denotes the ratio of the leading threshold mass M_B^{Th} of the bag to its mean mass M_B. Clearly for different bags the range of ξ_B value can be between 0 and 1. However, according to above results the bags with $\xi_B \to 1$ should have been essentially enhanced and sharpened as the ordinary hadrons. Moreover, according to (1) in this case for $T \ll T_B^+$ the QG bags should have had a small width $\Gamma_B^N \simeq \frac{T T_B^+}{T_B^+ - T} \ln(2)$ and, hence, such QG bags should have been stable or, in other words, these bags can be observed!

Our analysis shows that for the temperatures $T \in [80; 90]$ MeV the bags with $\xi_B \to 1$ can have sufficiently long eigen life-time of about $\tau_B \sim \frac{1}{\Gamma_B^N} \leq \frac{1}{T \ln(2)} \simeq 3.3 \pm 0.3$ fm/c. These estimates allow us to make the second important conclusion that *an appearance of sharp resonances (baryonic or/and mesonic) with the width in the interval between 50 to 70 MeV* at the chemical FO temperatures close to $T_{QGB} \simeq 85 \pm 5$ MeV *that have the mass above 2.5 GeV and that are absent in the tables of particle properties would be a clear signal of the QG bag formation.* Note that the chemical FO temperatures about $T_{QGB} \simeq 85 \pm 5$ MeV correspond to $\sqrt{s_{NN}} \in [4.5; 5]$ GeV [1, 2], which is in the range of the Dubna Nuclotron and NICA energies of collision. This energy range sets the kinematic upper limit for the QG bag searches, whereas the value of minimal mass of QG bags, $M_0 \simeq 2.5$ GeV, fixes the lower limit for the searches.

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RELATIVISTIC THEORY OF NUCLEON-NUCLEON INTERACTION

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Recent developments of the covariant Bethe–Salpeter (BS) approach [1] with the use of the separable interaction for the deuteron are reviewed. The procedure of the construction of the separable nucleon-nucleon (NN) interaction is discussed. Two different methods of a relativistic generalization of initially nonrelativistic form factors parametrizing the kernel are considered. The BS formalism with the separable interaction is demonstrated to provide good results on description of NN phase shifts. Thus, the neutron-proton interaction for the total angular momentum $J = 0, 1, 2$ partial state is obtained. Parameters of the kernel are defined from the description of phase shifts and low-energy characteristics in the elastic neutron-proton scattering. In order to take into account inelasticities the real-valued separable potential elaborated earlier was extended complex one. Then the description of the inelasticity parameter comes out of the imaginary part introduced in the potential. The complex potential parameters are obtained using the available elastic neutron-proton scattering experimental data up to 3 GeV. A signal of wide dibaryon resonances in the $^3P_0^+$ partial wave state is discussed [2] - [8].

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STATUS AND RECENT RESULTS OF THE ATLAS EXPERIMENT

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The Large Hadron Collider at CERN has resumed its operation in 2012 by showing a stable performance at 4 TeV per proton beam energy and aiming to provide enough statistics for the Higgs boson discovery. ATLAS is one of four major experiments accumulating data since the LHC start-up. The status of the detector and its performance are presented in the talk together with the highlights of main results, including Higgs boson observation, study of the Standard Model processes and heavy ion physics. The ATLAS upgrade plans are presented as well.

RECENT RESULTS OF THE STUDY OF ADS WITH 500kg NATURAL URANIUM TARGET ASSEMBLY QUINTA IRRADIATED BY DEUTERONS WITH ENERGIES FROM 1 TO 8 GeV AT JINR NUCLOTRON

[1]J.Adam, A.Baldin, A.Berlev, W.Furman, N.Gundorin, Zh.Hushvaktov, M.Kadykov, Yu.Kopatch, E.Kostyukhov, I.Kudashkin, A.Makan'kin, I.Mar'in, A.Polansky, A.Rogov, V.Pronskikh, V.Schegolev, A.Solnyshkin, V.Tsupko-Sitnikov, S.Tyutyunnikov, A.Vishnevsky, N.Vladimirova, A.Wojciechowski, L.Zavorka
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[7]M.Suchopar, O.Svoboda, J.Vrzalova, V.Wagner
[8]Ch.Stoyanov, O.Yordanov, P.Zhivkov
[9]M.Shuta, E.Strugalska-Gola, S.Kilim, M.Bielevicz
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The study of basic properties of the ADS presented in the previous Baldin seminar [1] was continued during the 2011-2012. For these experiments, uranium target assembly has been upgraded: the entrance window was created to reduce the albedo of the incident beam and a section was added to keep the effective mass of uranium to the beam axis. The new target assembly with a mass of 500 kg of natural uranium metal (diameter ~30cm and length 65cm) was named QUINTA. During the three runs of JINR NUCLOTRON the target assembly (TA) QUINTA was irradiated by deuterons with energies from 1 to 8 GeV and the total number of deuterons on the target of (3-5) 10^{13} at each energy.

There were measured the energy spectra of prompt neutrons inside and outside the target assembly and the time spectra of fission delayed neutrons (DN) between accelerator bursts. Beside that the spatial distributions of fission rates inside TA have been measured with aid of solid state track detectors and independently by activation method. The last method was used for measurements of ^{239}Pu nuclei production. All these measurements were made with the original TA QUINTA as well as with TA surrounded by a 10 cm thick lead blanket.

Total numbers of fissions and produced ^{239}Pu nuclei obtained by integration over QUINTA volume and normalized to one incident deuteron and one GeV were constant within experimental errors of about 15 % for the whole deuteron energy range. But the amount of produced ^{239}Pu nuclei increased by about 60% in measurements with a lead blanket, while the numbers of fissions remained virtually unchanged The group analysis of DN time spectra indicates a growth in the average energy of the neutrons initiating fission of target nuclei from 15 to ~ 45 MeV with an increase in energy of the incident deuterons from 1 to 8 GeV. This result should be verified by experiments planned at the end of 2012.

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BC, PaC AND SePaC METHODS FOR FRACTAL ANALYSIS OF EVENTS

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Results of analysis of wide class of fractals using the Box Counting, P-adic Coverage and System of Equations of P-adic Coverage methods are presented. Methods are described and comparison underlying hypotheses is given. The parameters of algorithms - χ^2_{lim} for BC, P_{Max}, χ^2_{lim} for PaC, and P_{Max}, Dev for SePaC methods, are discussed. Efficiency of reconstruction of fractal dimension D_F, number of level N_{lev} and P-adic coverage P is studied. Procedures for search for optimal values of parameters χ^2_{lim} , P_{Max}, and Dev for determination of D_F, N_{lev}, and P for these methods are developed. The features of PaC and SePaC methods for analysis of fractals with independent and dependent partition are noted.

MEASURING THE PHASE BETWEEN STRONG AND EM J/ψ DECAY AMPLITUDES

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QCD is certainly a well established theory for the strong interactions. Yet several physics topics which could be investigated with modern facilities can still offer various test of this theory. The investigation of the kinematic region near J/ψ production can provide a check of the QCD perturbative approach. In this energy range, an interference between the resonant $e^+e^- \rightarrow J/\psi \rightarrow$ hadrons and the non-resonant $e^+e^- \rightarrow$ hadrons amplitudes can in principle occur. A perturbative approach suggests that those amplitudes are expected to be all almost real, i.e. the relative phase between the above cited amplitudes is expected to be $0°/180°$, depcting hence the full interference scenario. Nevertheless, data available in the literature concordantly suggest a relative phase of $90°$ and, hence, the no interference scenario. An experimental approach able to provide a measurement of the relative phase in a model independent way, and in particular its deployment in the BESIII scenario, will be discussed in details.

DETERMINATION OF MASS SPECTRUM AND DECAY CONSTANTS MESONS CONSISTING OF THE c AND b QUARKS

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On the basis of investigation of the asymptotic behaviour of the correlation functions of corresponding field currents with the necessary quantum numbers is proposed an analytic method [1] for the determination of mass spectrum and decay constants mesons consisting of the c and b quarks with relativistic corrections. The dependence of the constituent mass of quarks on the current mass and on the orbital radial quantum numbers is analytically derived. The mass and wave functions of mesons are determined via eigenvalues of nonrelativistic Hamiltotonian in which the kinetic energy term is defined by the constituent mass of bound-state forming particles, and the potential energy term is determined by the contributions of every possible type of Feynman diagrams with exchange of gauge field. In the framework of our approach determined the mass splitting between the singlet and triplet states and calculated the $E1$ transition rates in the $\bar{c}c$, $\bar{b}b$ and $\bar{b}c$ systems. The Table 1. some our numerically results for the mass of mesons, and the constituent mass of quarks and decay constants of mesons are represented.

Table1. *The mass spectrum and decay constants mesons consisting of the c and b quarks. The experimental data from Ref. [2].*

		$\bar{c}c$	$\bar{b}b$	$\bar{b}c$
$S=0$	μ_c GeV	1.42862	-	1.51306
	μ_b GeV	-	4.73493	4.68082
	M_{our} MeV	2980.05	9400.04	6.2773
	M_{exp} MeV	2980.3 ± 1.2	-	6277 ± 4
	$\lvert\Psi(0)\rvert^2$ GeV^3	0.047003	0.196457	0.0525517
	f_η GeV	0.435053	0.500795	0.316955
$S=1$	μ_c GeV	1.47617	-	1.53652
	μ_b GeV	-	4.75281	4.71302
	M_{our} MeV	3096.44	9460.3	6330.71
	M_{exp} MeV	3096.916 ± 0.11	9460.3 ± 0.26	-
	$\lvert\Psi(0)\rvert^2$ GeV^3	0.1004	0.5973	0.219078
	f_η GeV	0.62372	0.8704	0.644412

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ANALYSIS OF DIFFERENCES ON PSEUDORAPIDITY MULTIPLICITIES SPECTRUM AT LHC AND UA1/UA5 EXPERIMENTS

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ATLAS experiment measured lower transverse momentum spectrum of charged particle multiplicity for proton-proton collisions at 900 GeV e.c.m. than UA1 experiment for proton-antiproton collisions at same energy. CMS and ALICE experiments confirmed ATLAS measures. This effect is in clear disagreement with most models, but was predicted by low constituent model.

Difference between multiplicities was estimated as 20% from analysis of transverse momentum spectrum. This value has large uncertainty and need to be improved.

To improve estimation of proton-proton and proton-antiproton multiplicity difference, one should use not only transverse momentum spectrum, but pseudorapidity multiplicities spectrum. Straightforward comparison of ATLAS and UA1/UA5 data is impossible because of significantly different kinematic regions of data.

Common parametrizations of transverse momentum spectrum were applied in this work to make comparison between ATLAS and UA1/UA5 data. Another applied way to compare data is PYTHIA based parametrisations, then one gets transverse momentum spectrum at low momentum from generated particles distributions. Improved estimation of proton-proton and proton-antiproton multiplicity difference is consistent with low constituent model.

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THE SUPERB PROJECT

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The SuperB factory is planned to be built on the Tor Vergata Campus near Roma (Italy) by 2017. With an integrated luminosity goal larger than 75 ab^{-1}, this project will be focused on searching for new physics phenomena. Rare processes and CP-violation effects in beauty, charm and tau particles decays sensitive to new physics will be studied with high precision. The bulk of data will be collected at the $\Upsilon(4S)$ resonance, however, specific assets of the asymmetric energy e^+e^- collider provide an opportunity to take data at a wide center-of-mass energy interval from the charm threshold to the $\Upsilon(5S)$. The physics prospects of this ultra-high luminosity e^+e^- collider will be presented in detail as well as the very innovative concepts guiding the machine and detector designs.

THE SIGNALS OF PARTIAL RESTORATION OF CHIRAL SYMMETRY IN MEDIUM AT INTERMEDIATE ENERGY: EXPERIMENTAL DATA VS. THEORY

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Hadrons, injected inside nuclei, apparently change some of their properties. The study of in-medium properties of hadrons has attracted quite some interest among experimentalists and theorists because of a possible connection with chiral symmetry restoration in hot and/or dense matter. Experiments using relativistic heavy ions are aimed to produce a system at very high densities and connected with that very high temperatures. In their dynamical evolution they run through various states, from an initial high-nonequilibrium stage through a very hot stage of a new state of matter (QGP). Any observed signal necessarily represents a time-integral over all these physically quite distinct states of nuclear matter. On the contrary, in experiments with microscopic probes on cold nuclei one tests interactions with nuclear matter in a well-known state, close to cold equilibrium. Even though the density probed is always smaller than the nuclear saturation density, the expected signals are as large as those from ultrarelativistic heavy-ion collisions.

In this talk a variety of aspects of in-medium behavior of hadrons are reviewed with an emphasis on experimental data. Examples for theoretical predictions of in-medium effect from scattering and reaction processes with K^+ beams below 800 MeV/c are given. It is also emphasize that final state interactions can have a famous effect on observables and thus have to be intended as part of the theory. This is demonstrated with examples from neutrino-nucleus deep inelastic interactions. In the end, the possibility to obtain hadron formation times in high-energy neutrino-induced reactions is demonstrated.

PRODUCTION OF HADRONS AT LARGE TRANSVERSE MOMENTUM IN 50 GeV p-NUCLEUS COLLISIONS

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A.Yu. Kalinin, A.V. Korablev, A.N. Krinitsyn, V.I. Kryshkin, N.V. Kulagin, V.V. Skvortsov,
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To study quark structure of nucleus there are measured the high p_T charged hadron production in collision of 50 GeV protons off nuclear targets (Be,Al,W) using double arm spectrometer. The single hadrons ($\pi^{\pm}$, $K^{\pm}$, p) flying at 90^0 in c.m.s. and hadron pairs with high effective mass (produced back to back in c.m.s.) were recorded simultaneously.

We present measurements of two-particle correlation function and A-dependencies for coplanar and noncoplanar hadron pairs.

RECENT HEAVY ION RESULTS FROM STAR

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Over the past decade the STAR experiment at Relativistic Heavy Ion Collider had successfully collected data at a number of center-of-mass energies with a variety of beam species. This allowed our diverse scientific program to flourish. In this talk I will review selected recent results in three major areas of STAR's experimental studies: new developments in the studies of medium properties with hard penetrating probes; current status and future plans for the STAR heavy flavor program; and the progress of the ongoing search for the QCD critical point.

THE WAY FOR ESTIMATION OF SPACE-TIME PARTICLE PRODUCTION VOLUME IN COLLIDING BEAMS

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Particle energy – time relation or particle energy quantum rule ($\mathbf{E_T\,\Delta T = E\,\Delta\tau = n\,h}$) is found in the way of studying particle scattering processes (E_T - particle transverse energy or transverse mass, E – its full energy, ΔT - particle production time, Δτ – corresponding proper time, h – Plank constant and n is an integer number). This relation for n=1 was applied for estimation of the space –time particle production volume in pp- collisions at LHC-energies ($\sqrt{s}$ =7 TeV). The proposed attitude may be usefull for the investigation cumulative and subthrehold processes and for the nuclear mater density estimation.

The investigation has been performed at the Laboratory of High Energy Physics, JINR.

SPECTROSCOPY AND REGGE TRAJECTORIES OF HEAVY QUARKONIA AND BC MESONS

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The mass spectra of charmonia, bottomonia and Bc mesons are calculated in the framework of the QCD-motivated relativistic quark model based on the quasipotential approach. The dynamics of heavy quarks and antiquarks is treated fully relativistically without application of the nonrelativistic v2/c2 expansion. The known one-loop radiative corrections to the heavy quark potential are taken into account perturbatively. The heavy quarkonium masses are calculated up to rather high orbital and radial excitations (L = 5, nr = 5). On this basis the Regge trajectories are constructed both in the total angular momentum J and radial quantum number nr. It is found that the daughter trajectories are almost linear and parallel, while parent trajectories exhibit some nonlinearity in the low mass region. Such nonlinearity is most pronounced for bottomonia and is only marginal for charmonia. The obtained results are compared with the available experimental data, and a possible interpretation of the new charmonium-like states above open charm production threshold is discussed.

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CATHODE PAD CHAMBERS AT NICA/MPD

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Covering pseudorapidity interval $2 < |\eta| < 3$, the Cathode pad chambers (CPC) are part of the tracking system of the MPD detector. The CPC tracking abilities depend on its geometrical layout which defines the detector occupancy and errors of reconstructed track coordinates. This MC study presents the method for estimating track coordinates along with their experimental errors which are subsequently used in the tracking algorithm in order to determine tracks geometric and kinematic characteristics.

FORWARD-BACKWARD MULTIPLICITY CORRELATIONS IN pp COLLISIONS IN ALICE AT 0.9, 2.76 AND 7 TeV

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We present the results from the analysis of the multiplicity correlations in pp collisions at $\sqrt{s} = 0.9$, 2.76 and 7 TeV, recorded with the ALICE detector. We studied separated pseudorapidity intervals (forward and backward "windows") in the central region ($|\eta| < 0.8$). Correlation coefficients were obtained for various widths and positions of these windows. Strong dependence of the multiplicity correlation coefficient on the width of the pseudorapidity windows is reported. In addition, we observe an increase of the correlation strength with the collision energy. Results are discussed and compared to PYTHIA simulations.

INFLUENCE OF GROUND-STATE VIBRATION AND DEFORMATION OF NUCLEI ON THE ELLIPTIC FLOW

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The eccentricity of the interaction zone and its fluctuations are considered to be primarily responsible for the Elliptic flow strength and its fluctuations in relativistic heavy ion collisions. We will describe, to what extent the ground-state deformation of nuclei being collided can influence the initial eccentricity and its fluctuations. Ground-state vibration of nuclei and the influence of this phenomenon on the initial state eccentricity in relativistic collisions of nuclei will be discussed.

INFRARED CONFINEMENT AND MESON SPECTROSCOPY

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Quark-antiquark bound states are studied within a relativistic quantum-field model based on the infrared confinement. The conventional meson spectrum is determined by a master equation similar to the ladder Bethe-Salpeter equation. Masses of light, intermediate and heavy mesons are estimated in a wide range of scale (up to 10 GeV). In doing so we revealed a new, specific infrared-finite behavior of the QCD effective coupling in the low-energy domain.

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ON POSSIBLE ROLE OF NON-$Q\bar{Q}$ ADMIXTURES IN LIGHT (PSEUDO)SCALAR MESONS

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The lowest mass and next to lowest mass (pseudo)scalar multiplets are treated as the ground and radial-excited pseudoscalar nonets, the ground scalar $(2q, 2\bar{q})$ - and the P-wave $(q\bar{q})$ scalar nonets and possible glueball and higher multiquark state residing in the interval of mass ≤ 1.7 GeV.The Gell-Mann-Okubo and Schwinger-type mass formulas are used to present and explore the mixed mass-matrices and the flavor structure of the respective physical meson states.

WITTEN PARAMETER IN THE $SU(2)$-GLUEDYNAMICS

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Confinement is the fundamental property of hadronic matter. The spectrum of the elementary particles can't be understood within QCD without this property. This feature results from string-like interaction between quarks at large distances. One of the possible explanation this interaction is condensation of magnetic monopoles in the vacuum [1]. According to t'Hooft [2], the monopoles can arise from the partial breaking of the gauge symmetry. In this work we consider $SU(2)$ symmetry breaking with conservation of $U(1)$ symmetry.

The surface operator [3] proposed by Witten [4, 5] is a quantity sensitive to existence of monopoles. The parameter determine flow of the chromomagnetic field through a closed surface. All calculations are performed in the lattice approach with $SU(2)$ gluedynamics. We use multilevel and multi-hit algorithms on the supercomputer for obtain the best statistic.

In the Abelian vacuum (in electrodynamics) the flow vector of magnetic field through a closed surface is identically zero:

$$\oint \mathbf{H} \cdot d\mathbf{S} \equiv 0. \tag{3}$$

In the lattice calculation we use phase $e^{\imath\varphi}$, therefore the identity (3) acquires the next form:

$$e^{\imath\kappa \oint \mathbf{H} \cdot d\mathbf{S}} \equiv 1, \tag{4}$$

where κ is dimensional-eliminate coefficient. This identity holds in the Abelian theory with continuous simply connected space. If space-time has non-trivial topology or group symmetry is non-Abelian, then identity (4) does not necessarily hold. Then, in general case lattice quantum chromodynamics has:

$$e^{\imath\kappa \sum\limits_k \mathbf{H}_k \cdot \Delta\mathbf{S}_k} \neq 1, \tag{5}$$

where $\mathbf{H}_k$ - vector of magnetic field on the k-th lattice plaquette, $\Delta\mathbf{S}_k$ - area of the his surface (with the normal vector to the center of the plaquette), and integral is calculated through the closed surface. Closed surface is compiled by the lattice plaquettes.

Thus, we will call Witten parameter the following value:

$$W(S) = Re \prod_S e^{\imath\theta_p}, \tag{6}$$

Here θ_p is plaquette angle and S is surface. This parameter senses the chromomagnetic field. Phase is changed in this value of angle when moving along the contour of the plaquette. This phase is related with magnetic field flow through plaquette surface:

$$\kappa \int_S \mathbf{H} \cdot d\mathbf{S} = \kappa \int rot\mathbf{A} \cdot d\mathbf{S} = \kappa \oint \mathbf{A} \cdot d\mathbf{l} = \theta_p, \tag{7}$$

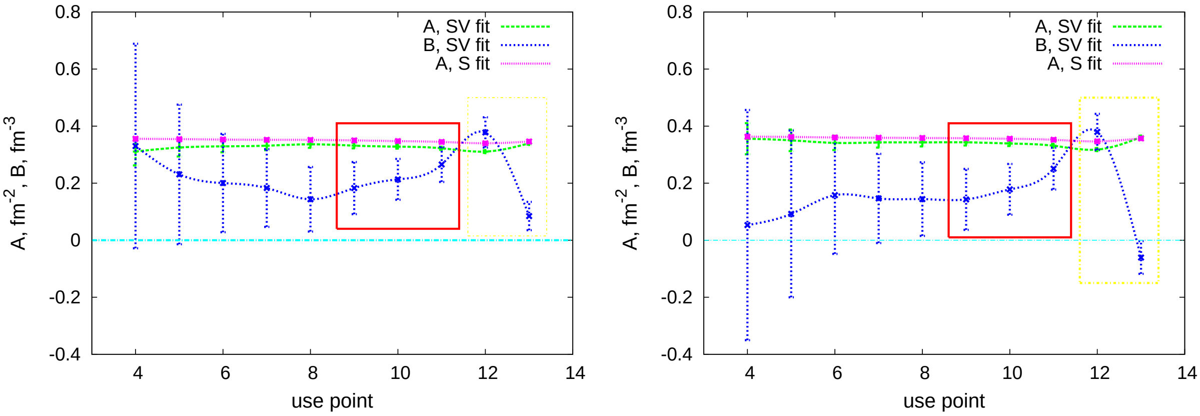

Figure 3: Witten parameter fitting in the confinement phase (leftward) and in the deconfinement phase (rightward). Where A - surface coefficient, B - volume coefficient, SV fit - fitting with use dependence from area surface and volume, S fit - use dependence only from area surface. Red solid rectangle is the best area for get results.

where integration over $d\mathbf{l}$ is carried out on the path covering the surface S.

We can rewrite magnetic field flow:

$$\int_S \mathbf{H} \cdot d\mathbf{S} = \int_S F_{ik}\, d\sigma_{ik}, \tag{8}$$

where F_{ik} - the gauge field tensor, $d\sigma_{ik}$ - surface element (here we do not distinguish between upper and lower indices, because all calculations are performed in Euclidean space-time after Wick rotation), $i,\ k = 1,\ 2,\ 3$ - space direction. In this work we consider gauge field theory without particle with $SU\,(2)$ group symmetry broken up to $U\,(1)$ group symmetry. Thus θ_p is related with $F_{\mu\nu}$ by the following formula:

$$F_p = \widehat{1}\, cos\, \theta_p + \imath\, n_i \sigma_i\, sin\, \theta_p, \tag{9}$$

where n_i - vector on the unit sphere, σ_i - Pauli matrices, F_p is the value of the gauge field tensor $F_{\mu\nu}$ on the plaquette. Then, θ_p is equal $\arccos\left(\frac{1}{2} Tr\, F_p\right)$. The range of function $\arccos\,(x)$ is $[0, \pi]$. In the gauge group $U\,(1)$ the range of variation of the angle is $[0, 2\pi]$. Thereby, symmetry is broken to $U\,(1)$ up to a random phase $\varphi \in Z_2$.

In the lattice approach we select cube in the 3d space with some length of the edge on the lattice. The phase on the surface of the cube is calculated on the each plaquetts and result is obtained by summation these phases. Of course we remember sign of phase, it determined by normal vector to the plane of cube. After then we calculate our parameter at different point in the lattice configuration and average them. The final result is obtained by averaging on the set of configurations.

We consider cubic with length of the edge from $1a$ to $13a$ (a is the lattice scale), which corresponds surface from 6 to 1014 plaquetts. For best accuracy we use multilevel [6], multi-hit [7] algorithms and MPI (Message Passing Interface) parallelism for fast calculation. We use 144 cores for each phase.

All calculation performed on 50 configurations in 1000 points on the each lattice configuration. The behaviour of Witten parameter is fitted by next dependence:

$$W(S) = e^{-AS} \quad and \quad W(S,V) = e^{-AS-BV}, \tag{10}$$

where A is surface coefficient, B is volume coefficient, S is area surface, V is volume of cube.

For small surface we have good statistic and bad approximation. Therefore we studied dependence of coefficient A, B from quantity use point in fitting. We discard n first point for small surface and the remaining points are fitted by dependence (10). Figure 3 is shown that. Small quantity of use point makes big dispersion for coefficient A, B, thus we can't use them in analysis. The most appropriate area for conclusion is singled out by red solid rectangle. It turns, that Witten parameter depend from area surface and volume in two phases. Consequently it isn't the order parameter for phase transition confinement-deconfinement.

The result is multilevel algorithm stated on the close surface. This algorithm is tested on the Witten parameter calculating. Accuracy increased by two orders of magnitude with respect calculating without the use of the algorithm. Finally, Witten parameter isn't the order parameter for phase transition confinement-deconfinement.

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THE DIFFERENTIAL CROSS-SECTION ON DP-ELASTIC SCATTERING AT 880 MEV OBTAINED AT NUCLOTRON

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The results on the cross-section of dp-elastic scattering reaction obtained at 880 MeV at internal target of Nuclotron are presented. The measurements have been performed using CH_2 and C targets and kinematic coincidence of signals from scintillation counters. The cross-section data are compared with theoretical predictions and results of previous experiments.

MICROSCOPIC PION-NUCLEON AND NUCLEUS ELASTIC SCATTERING AT INTERMEDIATE ENERGIES

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On the basis of the one-boson-exchange (OBE) method a microscopic potentials of the pion-nucleon and nucleus has been derived. The elastic scattering of both the pion(+) and the pion(-) at energies 116, 180 and 292 MeV from nucleon and also from Ca(40) nucleus are calculated. The calculated differential and total cross sections show good agreement with the corresponding experimental data available at the above energies.

APPLICATION OF WAVELET ANALYSIS TO STUDY THE PARAMETERS OF GROUPS OF RESONANCES

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We show the usefulness of wavelet analysis to resolve the structures in experimental data. Due to good scaling properties of the wavelets the data can be studied with various resolutions, which gives a model independent way to separate the resonances from noise contribution, the background, and each other. The WA is much less sensitive to the noise than other types of analysis and allows substantially reduce the role of statistical fluctuations. As a particular example we analyze the $e^+e^- \to$ hadrons data to study the charmonium resonances. Using data from several different experiments masses and widths of the four lowest mass resonances are obtained.

DEUTERONS BEAM PARAMETERS MEASUREMENTS OF THE NUCLOTRON

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The experimental subcritical setup "QUINTA" irradiation by deuteron beams of energies 1, 4, 6 and 8 GeV is described in the paper. The experiments were done in Laboratory of High Energy Physics (JINR, Dubna, Russian Federation). The beams were produced by superconducting, strong focusing synchrotron named Nuclotron.

The experimental subcritical setup contains five sections. Each section is composed of uranium rods arranged in the form of hexagonal (triangular) lattice with pitch size of 3.6 cm. Whole setup contains total of 512.56 kg of natural uranium.

The axis of the setup was aligned with beam axis with the help of the adjustable stand under the whole setup. The alignment of the beam center with the center of the setup was achieved by examining Polaroid films placed in front of the target and exposed to a couple deuteron pulses prior to the installation of the sample plates and the start of the main irradiation. Deuteron's beams shape and position on the target were obtained from track density distribution on the irradiated track detectors. Sensors made of ^{nat}Pb foils and artificial mica as solid state nuclear track detectors (SSNTD) were used for registration $^{Nat}Pb(d,f)$ reaction. The coordinates of the deuteron beam centre and full width at half maximum of the distributions were obtained from the Gaussian fits of the deuteron beam in X- and Y-axis. The fraction of the beam striking the fissionable material and number of deuterons gone out of the setup were calculated.

The results obtaining during the experiments were used to determine beam position on the target, beam parameters (beam shape and beam size).

It is shown that more precise primary alignment of the target along the beam axis is needed. Or, if it is not possible, the central part of the setup (uranium rods, d=3,6 cm) should be replaced by a lead target with bigger diameter, in order to avoid beam losses in the gaps between the rods.

The simulations of the experiment were done with a FLUKA2011 Monte-Carlo code. Comparison experimental results and simulation is also presented.

MULTIQUARK STATES IN THE COVARIANT QUARK CONFINEMENT MODEL

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We refine [1] the relativistic constituent quark model developed in our previous papers to include the confinement of quarks. It is done, first, by introducing the scale integration in the space of alpha-parameters, and, second, by cutting this scale integration on the upper limit which corresponds to an infrared cut-off. Such trick allows one to remove all possible thresholds available in the initial quark diagram. The cut-off parameter is taken to be the same for all physical processes. We adjust other model parameters by fitting the calculated quantities of the basic physical processes to available experimental data.

As an application, we calculate [2] in a parameter free way, the form factors of the $B(B_s) \to P(V)$-transitions in the full kinematical region of momentum transfer. By using the calculated form factors, we evaluate the widths of the nonleptonic B_s-decays into $D_s^- D_s^+, D_s^{*-} D_s^+, D_s^- D_s^{*+}$ and $D_s^{*-} D_s^{*+}$. These modes give the largest contribution to $\Delta\Gamma$ for the $B_s - \bar{B}_s$ system. We also treat the nonleptonic decay $B_s \to J/\psi + \phi$. Although this mode is color suppressed this decay has important implications for the search of possible CP-violating New Physics effects in $B_s - \bar{B}_s$ mixing.

We extend [3] our approach to the baryon sector. In our numerical calculation we use the same values for the constituent quark masses and the infrared cutoff as have been used in the meson sector. In a first application we describe the static properties of the proton and neutron, and the Λ-hyperon (magnetic moments and charge radii) and the behavior of the nucleon form factors at low momentum transfers. We discuss in some detail the conservation of gauge invariance of the electromagnetic transition matrix elements in the presence of a nonlocal coupling of the baryons to the three constituent quark fields.

We further explore [4-5] the consequences of treating the X(3872) meson as a tetraquark bound state. We calculate the decay widths of the observed channels $X \to J/\psi + 2\pi(3\pi)$, $X \to \bar{D}^0 + D^0 + \pi^0$ and $X \to \gamma + J/\psi$. For a reasonable value of the size parameter of the X(3872) meson we find consistency with the available experimental data. We also calculate the helicity and multipole amplitudes of the process $X \to \gamma + J/\psi$, and describe how they can be obtained from the covariant transition amplitude by covariant projection.

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PERTURBATIVE STABILITY OF THE QCD PREDICTIONS FOR THE RATIO $R = F_L/F_T$ AND AZIMUTHAL ASYMMETRY IN HEAVY-QUARK LEPTOPRODUCTION

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We analyze the perturbative and parametric stability of the QCD predictions for the Callan-Gross ratio $R(x, Q^2) = F_L/F_T$ and azimuthal $\cos(2\varphi)$ asymmetry in heavy-quark leptoproduction. Our analysis shows that large radiative corrections to the structure functions cancel each other in their ratio $R(x, Q^2)$ [1, 2] and azimuthal asymmetry [3] with good accuracy. We provide compact analytic predictions for $R(x, Q^2)$ and asymmetry in the case of low $x \ll 1$. Simple formulae connecting the high-energy behavior of the Callan-Gross ratio and azimuthal asymmetry with the low-x asymptotics of the gluon density are derived. It is shown that the obtained hadron-level predictions for $R(x, Q^2)$ and azimuthal asymmetry are stable at $x \ll 1$ under the DGLAP evolution [4, 5] of the gluon distribution function.
Concerning the experimental aspects, we propose to exploit the observed perturbative stability of the Callan-Gross ratio and $\cos(2\varphi)$ asymmetry in the extraction of the structure functions from the corresponding reduced cross sections. In particular, our obtained analytic expressions simplify essentially the determination of $F_2^c(x, Q^2)$ and $F_2^b(x, Q^2)$ from available data of the H1 Collaboration [6, 7]. Our results will also be useful in extraction of the azimuthal asymmetries from the incoming COMPASS data on charm leptoproduction.
The variable-flavor-number-scheme predictions for $R(x, Q^2)$ [1] and $\cos(2\varphi)$ asymmetry [8, 9] as well as the possibility to discriminate experimentally between the photon-gluon fusion and quark-scattering contributions to these quantities are also discussed.

Keywords: Perturbative QCD, Heavy-Quark Leptoproduction, Radiative Corrections, Callan-Gross Ratio, Azimuthal Asymmetry

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SOLVING BETHE-SALPETER EQUATION FOR THE SCATTERING STATES

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We present the first solution of the Bethe-Salpeter (BS) equation [1]:

$$
\begin{aligned}
F(p,p'',P) &= K(p,p'',P) - i\int \frac{d^4p'}{(2\pi)^4} K(p,p',P) \\
&\times \frac{1}{\left[\left(\frac{1}{2}P+p'\right)^2 - m^2 + i\epsilon\right]} \frac{1}{\left[\left(\frac{1}{2}P-p'\right)^2 - m^2 + i\epsilon\right]} F(p',p'',P),
\end{aligned}
$$

in Minkowski space for the scattering states, for the off-mass-shell amplitude, for the one-boson exchange (OBE) kernel K. Solving this equation is a difficult task because of the existence of many singularities in the integrand. The singularities, of course, are integrable in a mathematical sense (due to $i\epsilon$ in the propagators), but cannot be handled in a direct numerical way. Because of that, the BS equation for the scattering states was previously solved for the separable kernels (see for review [2]). For the OBE kernel, only the on-shell amplitude, determining the phase shifts, was found.

Our method (valid both for the bound and for the scattering states) is based on an explicit analytical treatment of all the singularities. It can be applied both to equation without the partial wave decomposition and to the partial wave one. For the present, we consider the case of spinless particles.

Using this method we first solve the bound state equation and reproduce our previous results, found in Minkowski space by another our method (see for review [3]).

We find that the BS results for the phase shifts and for the scattering length considerably differ from the ones given by the Schrödinger equation. The relativistic effects are significant even at small incident energy.

Above the meson creation threshold the phase shifts become imaginary. Then we calculate inelasticity.

The off-shell BS amplitude found in our work, after its generalization to the NN system, can be used for relativistic calculation of the deuteron electrodisintegration $ed \to enp$, which is an inelastic analogue of the deuteron e.m. form factors.

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OBSERVATION OF LIGHT NUCLEI FORMATION AS NUCLEAR COALESCENCE IN HEC AND CC-INTERACTIONS AT 4.2 A GeV/c

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The centrality dependences of light nuclei yields in HeC- and CC-interactions at 4.2 A GeV were studied as a function of collision's centrality. Number of identified protons was used as a parameter of centrality. In CC-interactions a peak in most central collisions was observed. Simulated data coming from Dubna Cascade Model could not describe the behavior of experimental data around the "region of peak". We think that reason of the peak is additional formation of light nuclei in dense nuclear matter. These light nuclei formed as a result of nuclear coalescence effect. Due to high density the protons and neutrons in same momentum space come close together and form nuclei. The behavior of average multiplicity of negative pions as function of the centrality gives some evidence of nuclear coalescence effect. Because one of the sources of negative pions in this area is reaction $n + n \rightarrow D + \pi^-$, so increasing the number of light nuclei accompanies with increasing the number of negative pions.

IRRADIATION HISTORY AND RESULTING ISOTOPE DECAY SCHEME INFLUENCE ON YTTRIUM GAMMA ACTIVITY

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Spallation neutrons produced during QUINTA setup irradiation react with Y89 samples producing a set of gamma active yttrium isotopes. The measured gamma activity used for isotope production calculation is a function of several parameters. This work is focused on two of them - on irradiation history and decay scheme. After introductory explanation of the both effects some QUINTA experiment results are shown as the illustrative examples.

RESONANCE RESULTS WITH THE ALICE EXPERIMENT IN PP AND PB-PB COLLISIONS AT LHC ENERGIES

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Short lived resonances have been reconstructed from their hadronic decay with the ALICE experiment at LHC. In pp collisions mesonic K*(892)0, phi(1020) and baryonic Delta++(1232), Sigma(1385), Lambda(1520), Xi(1530) resonances have been analysed. For Pb-Pb collisions results on the mesonic resonances are presented. Transverse momentum spectra, yields, particle ratios and comparison with Monte Carlo model predictions will be discussed.

PROBING OF THE TRANSVERSE MOMENTUM DEPENDENT PARTON DISTRIBUTIONS IN CUMULATIVE REACTIONS

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Analysis of data aimed at the determination of the mean transverse momentum squared, $< {P_t}^2 >$, of pions, kaons, antikaons, proton, and antiprotons produced in cumulative reactions reveals new aspects of the nuclear structure at small-distance scales. The extracted X-dependence of $< {P_t}^2 >$ exhibits two remarkable features. First, the values of the mean transverse momentum squared in the region of $X > 1$ significantly exceed those observed in the range of $X < 1$. Second, the values of $< {P_t}^2 >$ are different for various hadron types. Studying transverse momentum dependent parton distributions provide unique access to the orbital motion of partons inside nuclei.

NEUTRAL PION FLUCTUATION STUDIES AT U-70

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The results of -190 experiment (project Thermalization) in *pp* interactions at the SVD-2 setup are presented. The photons are registered by the electromagnetic calorimeter. MC simulation confirms the linear dependence between number of photons N_γ and the average multiplicity of neutral pions $<N_0>$. Multiplicity distributions of neutral pions, N_0, at the given total multiplicity, N_{tot}, including charged particles, N_{ch} , have been obtained with corrections on the setup acceptance, triggering and efficiency of the event reconstruction. The scaled variance of neutral pion fluctuations, $\omega = D/ < N_0 >$, versus total multiplicity evidences for the neutral pion number fluctuation growth over $N_{tot} = 18$ [1]. According to ideal pion gas model [2] this behavior may point to the pion condensate formation in high pion multiplicity system. This effect has been observed for the first time.

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GAUGE FIELD MASS PROBLEM IN NEW ASPECT

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The gauge field mass problem does not seem to be completed now. Higgs mechanism generates these masses in analogy with the masses of Cooper's pairs in superconductors. But the question is: are the Higgs masses of gauge fields the real masses of particles, which can be the sources of real gravity field or not? This talk is dedicated to different problems connected with elementary particle mass definition in real conditions.

Key words: global and local symmetries, gravity, gauge field theory, elementary particle mass.

DMITRIJ IVANENKO - EMINENT SCIENTIST AND PERSON

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In connection with 80th anniversary of the proton-neutron model of nucleus the short biography of the author of this model - prof. D.Ivanenko - is under discuss. His features as professional scientist and ordinary man are regarded also.

Key words: proton-neutron model of nucleus, gravity, gauge field theory, elementary particles.

QUASI-GROUP SYMMETRIES, STOCHASTIC PROCESSES AND THE HADRON STABILITY

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We offered to consider the charged pion decay as the physical process which illustrates the spontaneous breaking of the *SU*(3) symmetry to the *SU*(2)×*U*(1) symmetry [1]. As a result it might be worthwhile to do not increase the count of gauge fields beyond 8 as in the grand unified theory. For the realization of this purpose we shall use quasi-group symmetries which are the maximum likelihood ones for the stochastic processes description, characterizing any open systems. Of course structure tensor components $C^c_{ab}(x)$ must be solutions of corresponding differential equations

$$C^d_{[ab}C^e_{c]d} - \xi^i_{[a}\partial_{|i|}C^e_{bc]} = 0 \ ,$$

which generalize Jacobi identities [2] ($x \in M_4$; Latin indices *a*, *b*, *c*, *d*, *e* run the values of integers from 1 to 8 and Latin indices *i*, *j*, *k*, … run the values of integers from 1 to 4). (We evolve the Dirac hypothesis on the presence of the electrons sea with negative energies in the Universe for the explanation of the electrons stability with positive energies.) The assumption on the "sea" of quarks in the ground state allows using the Landau theory of the Fermi liquid considering observable particles as quasi-particles on the background of "sterile" neutrinos and "sterile" antineutrinos. The properties of the latter's must define the geometrical and topological properties of the space-time M_4. Personally it must not be the simply connected space if physical systems are considered at sufficiently low energies that allow explaining the charge quantization of observable particles. As a result we forecast the appearance the new physics just at sufficiently high energies.

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ON THE POSSIBILITY OF MASSLESS NEUTRINO OSCILLATIONS

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Rigid limitations in the framework of initial assumptions and rigorous results, based on them, allow to make qualitative conclusion on the possibility of massless neutrino oscillations. Such oscillations can arise in the case if particles form a quartet. The quartet it is a state, which describes two pairs of particle-antiparticle by means of a single equation. In the case of the neutrino quartet oscillations are determined not by difference of the masses (mass m=0 for each pair), but by the distinction of spin states.

POSSIBLE DEVELOPMENT OF CUMULATIVE PARTICLE EXPERIMENTS WITH NICA FACILITY

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After collisions with projectiles, density fluctuation of nuclear matter may turn into multibaryon (MB) with chiral symmetry restored in its interior. This method of observation of the chiral phase transition has its advantages due to a relatively moderate number of secondary particles to be measured. We suggest to use a cumulative particle as a trigger for registration of MB decay products. Estimations show that its appearance is a signature of "deep cooling" of the MB, which brings it close to the unexcited state [1]. This gives a chance to separate MB from the secondary particle background. For separation of events with MB production, a role of intranuclear collisions of MB decay products should also be evaluated. We study experimental data taken (with a view to observation of the color transparency and the short range correlations) with the EVA spectrometer at BNL [2, 3] as a simplified form of the problem. Analysis of intranuclear interactions before and after hard scattering of protons on SRC leads to unexpected conclusion that wave function of ^{12}C has an admixture of states reminding a fusiform body.

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SMALL x BEHAVIOR OF PARTON DENSITIES

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It is shown that a Bessel-like behavior of the structure function F_2 at small x, obtained for a flat initial condition in the DGLAP evolution equations [1, 2], leads to good agreement with the deep inelastic scattering experimental data [3] from HERA.

Some disagreement at $Q^2 \sim 1$ Gev^2 can be explained by the importance of the BFKL contribution [4] in this area.

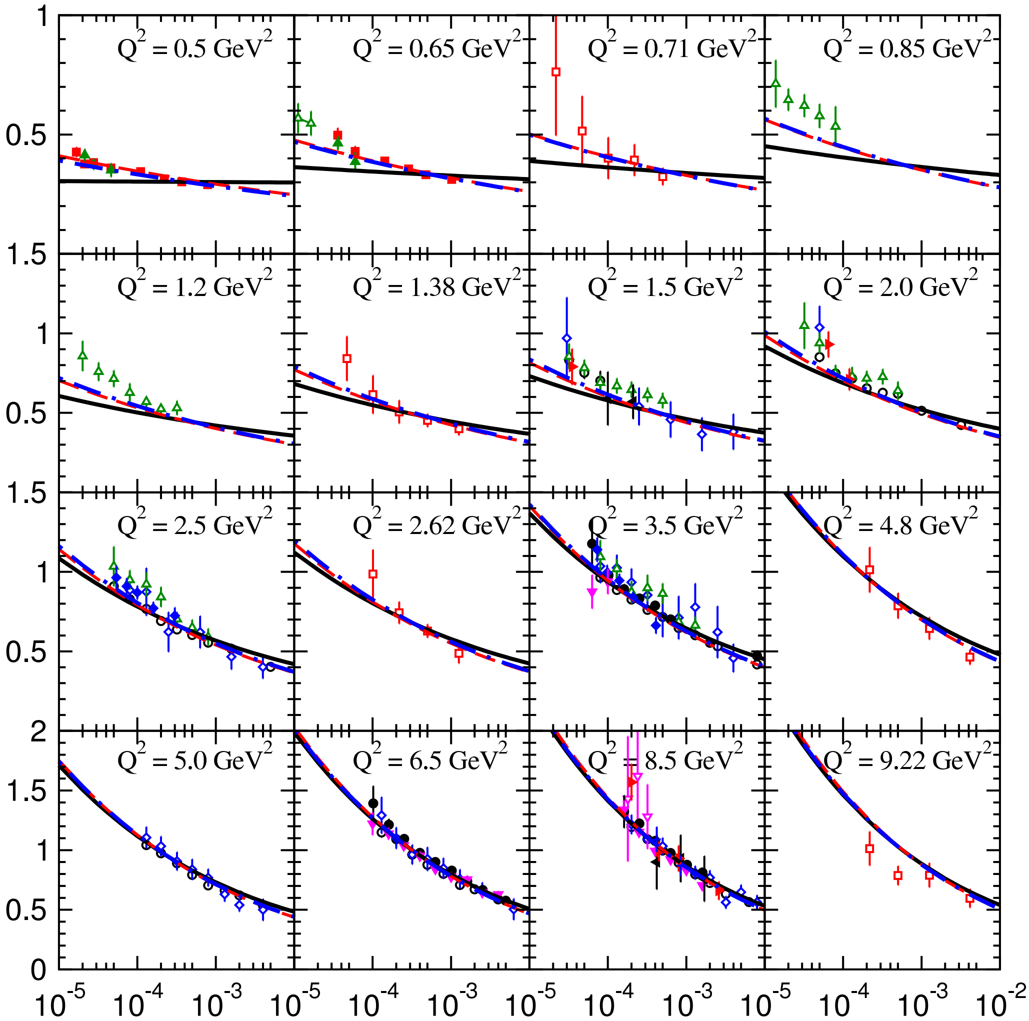

Figure 4: x dependence of the deep inelastic structure function $F_2(x, Q^2)$ in bins of Q^2 [2]. The experimental data from H1 (open points) and ZEUS (solid points) [3] are compared with the NLO fits for $Q^2 \geq 0.5$ GeV^2 implemented with the canonical (solid lines), frozen (dot-dashed lines), and analytic (dashed lines) versions of the strong-coupling constant.

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MODEL OF PP AND AA COLLISIONS FOR THE DESCRIPTION OF LONG-RANGE CORRELATIONS

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Soft processes in pp and AA interactions are considered in the framework of phenomenological model with color strings formation and fusion. Elementary parton collisions are realized in the model as the interaction of two colour dipoles from projectile and target nucleons. Modeling of the exclusive distributions of parton momentum fractions and transverse coordinates is performed. The interaction of colour strings in transverse plane is carried out in the framework of local string fusion model with the introduction of the lattice in the impact parameter plane and taking into account the finite rapidity length of strings. The parameters were fixed with experimental data on pp total inelastic cross section and charged multiplicity.

The model was used for the calculation of long-range correlations between the multiplicities (n) and the mean transverse momenta (pt) of charged particles. The dependence of n-n, pt-n, pt-pt correlations on the width and position of the backward and forward rapidity windows was studied.

Note that the model enables to describe the AA interactions without referring to the Glauber picture based on the concept of elementary nucleon-nucleon collisions. In this connection the charged multiplicity, the mean numbers of participant nucleons and binary collisions and their variances in the case of PbPb collisions were calculated and compared with the predictions of alternative models and the experimental data. The influence of different ways of centrality determination on the multiplicity fluctuations and long-range correlations was also estimated.

This work was partially supported by the RFFI grant 12-02-00356-a.

THE MCP-BASED SYSTEM FOR MONITORING SPACE-TIME CHARACTERISTICS OF CIRCULATING BEAM OF NUCLOTRON

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A new diagnostic system for circulating beams of Nuclotron based on microchannel plates (MCP) was developed in the framework of NICA project and experiments with extracted beams; the system was tested during four last runs of Nuclotron. The system provides measurement of the beam position with a spatial resolution of about 1 mm and a time resolution of up to 300 ns in an intensity range of 10^5 - 10^{10} for singly charged ions. The results of testing, advantages and limitations of this system are presented. The prospects of development of the monitoring and control system for accelerated and extracted heavy ion beams with required intensities and time structure are discussed.

”NON-ROSENBLUTH” BEHAVIOR OF THE PROTON FORM FACTORS AND THE VIOLATION OF THE CP-SYMMETRY

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One of the most interesting experimental results of the recent time is the so called ”non-Rosenbluth” behavior of the proton electromagnetic form factors in the scattering of the longitudinal polarized electron beams by the protons [1].

Ratio of the electric form factor to magnetic one was obtained in these experiments as linearly decreased function of the momentum transfers square. This result is in conflict with results of the scattering of nonpolarized electrons by proton. In these experiments the electromagnetic proton form factors are measured by the Rosenbluth's method, which gives for this ratio unity approximately.

In the present paper we will analyze the experimental results of *ep*-scattering with polarized and nonpolarized electrons in terms of possible CP-violation in the electromagnetic processes in the composite systems with strong interaction. Experimental observation of the anapole moment in the nucleus ^{133}Cs [2, 3] is clear evidence for this hypothesis.

For analysis we used special method of construction of the proton electromagnetic current operator (see, e.g. [4]) which is following from the general method of relativistic invariant parameterization of local operator matrix elements [5] (see [6] for detail).

It was obtained that this hypothesis about CP-violation leads to the emergence of the electric dipole form factor and the magnetic quadruple one of second kind (anapole form factor) in the matrix element of the proton electromagnetic current operator and in the corresponding cross section. It is shown that the contribution of the anapole form factor to the cross section of the nonpolarized *ep*-scattering is essential but this cross section has the Rosenbluth form in the region of modern experiments still. The strong deviation from Rosenbluth's behavior is observed at small scattering angles of electrons only.

The contribution of the anapole proton form factor leads to the elimination of conflict between the nonpolarized and polarized elastic *ep*-scattering. The estimation of the anapole form factor is produced in the region of the polarized *ep*-scattering. The static limits of the this form factor (anapole moment) equals to zero. The new values of the electric and magnetic form factors are obtained from analysis *ep*-scattering.

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HIGH ENERGY PROTONS FROM ^{12}C FRAGMENTATION

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Results of the FRAGM experiment performed at the ITEP heavy ion Tera-Watt-Accumulator are presented. Fragmentation of ^{12}C nuclei on Be-target was studied at six energies 0.2, 0.3, 0.6, 0.95, 2.0 and 3.2 GeV/nucleon. Fragments were registered at 3.5^o by double focus beam line spectrometer with scintillation counters and were separated by dE/dx and TOF measurements. Main attention was given to high momentum protons in cumulative region where x>1 ($x = p/p_0$ and $p(p_0)$ - proton (projectile) momentum per nucleon). The obtained x-spectra cover up to six orders of invariant cross section magnitude and up to 2.4 in the x value. These spectra were analyzed in multiquark cluster model with fragmentation functions given by Quark-Gluon Strings model. In the framework of this analysis we estimated relative probabilities of six- and nine-quark clusters in comparison to single nucleon component in ^{12}C. These probabilities were found to be about 10% and 0.5% respectively. The values are in qualitative agreement with estimation of two- and three-nucleon short-range correlation probabilities in ^{12}C nuclei made in (e,e') experiment at TJNAF. In purely phenomenological approach we fitted proton kinetic energy spectra in a rest frame of projectile nucleus with two exponents and obtained the temperatures in evaporation and cumulative regions from the slope parameters. At studied energies the temperature in the cumulative region rises with projectile energy but is still smaller than measured in pA-interactions at high energy. Target dependence of these temperatures was measured with high precision at 0.3 GeV/nucleon for Be, Al, Cu and Ta and showed independence from target material.

DOUBLE PION PRODUCTION IN THE NP AND PP COLLISIONS AT 1.25 GeV WITH HADES

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We present measurement of double pion production in *np* and *pp* collisions at an incident beam energy of 1.25 GeV with the HADES spectrometer at GSI. The np- reactions were studied in *dp* collisions at 1.25 GeV/u using Forward Wall hodoscope aimed at registering spectator protons. High statistic invariant mass and angular distributions are obtained within the HADES acceptance which are compared to a different theoretical models.

NEW DATA ON THE DIFFERENTIAL CROSS SECTION OF DP-ELASTIC SCATTERING AT 2.5 GeV OBTAINED WITH HADES DETECTOR

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New results on the differential cross section in deuteron-proton elastic scattering are obtained at the deuteron kinetic energy of 2.5 GeV with the HADES spectrometer. The angular range of $69^\circ - 125^\circ$ in the center of mass system is covered. The obtained results are compared with the relativistic multiple scattering model calculation using the CD-Bonn deuteron wave function. The data at fixed scattering angles in the c.m. are in qualitative agreement with the constituent counting rules prediction.

DIFFERENTIAL CROSS SECTIONS AND ANALYZING POWERS IN THE $dd->{}^3Hen$ REACTION AT INTERMEDIATE ENERGIES

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The $dd \to {}^3Hen$ reaction is considered at the energies between 200 MeV and 520 MeV. The calculations are performed within relativistic multiple scattering model based on the Alt-Grassberger-Sandhas equations. The angular dependences of the differential cross section and vector and tensor analyzing powers are given in comparison with the experimental data.

STUDY OF STRANGE MATTER PRODUCTION IN THE HEAVY ION COLLISIONS AT NUCLOTRON

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It is proposed to install an experimental setup in the fixed-target hall of the Nuclotron with the final goal to perform a research program focused on the production of strange matter in heavy-ion collisions at beam energies between 2 and 6 A GeV. The basic setup will comprise a large-acceptance dipole magnet with inner tracking detector modules based on double-sided Silicon micro-strip sensors and GEMs. The outer tracking will be based on the drift chambers and straw tube detector. Particle identification will be based on the time-of-flight measurements. This setup will be sufficient perform a comprehensive study of strangeness production in heavy-ion collisions, including multi-strange hyperons, multi-strange hypernuclei, and exotic multi-strange heavy objects. These pioneering measurements would provide the first data on the production of these particles in heavy-ion collisions at Nuclotron beam energies, and would open an avenue to explore the third (strangeness) axis of the nuclear chart.

The extension of the experimental program is related with the study of in-medium effects for vector mesons decaying in hadronic modes. The studies of the NN and NA reactions for the reference is assumed.

OVERVIEW OF RECENT CMS RESULTS AT $\sqrt{s} = 7$ AND 8 TeV

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We discuss the results of searches for Higgs boson and various new physics phenomena in the pp collisions at 7 and 8 TeV delivered by LHC and collected with the CMS detector in 2011-2012. A new boson with mass near 125 GeV is observed above the expected background with most significant excess of events in the two decay modes gamma-gamma and ZZ, results for combination of five channels are presented. Limits for new physics phenomena with various experimental signatures (dileptons, diphotons, dijets, multijets, etc.) are set. Results on study of electroweak and QCD processes and heavy-ion physics are presented.

THE HALL D PHYSICS PROGRAM AT JLAB

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GlueX is one of the flagship experiments of the 12 GeV era at the Thomas Jefferson National Accelerator Facility (JLab). The energy of the electron accelerator at JLab is presently undergoing an upgrade from 6 GeV to 12 GeV and a 4th experimental hall (Hall D) is being added. The GlueX experimental apparatus consists of a tagged coherent bremsstrahlung photon beam incident on a liquid hydrogen target. The photoproduced mesons, which are created inside of a 2.2 T solenoid, will then pass through a pair of drift chambers and eventually deposit their energy into either of two calorimeters, depending on their respective angles. GlueX will attempt to map out the light meson spectrum and search for meson-gluon hybrids to better understand the confinement of quarks and gluons in quantum chromodynamics (QCD). There is little data on the photoproduction of light mesons and the GlueX experiment will exceed the current photoproduction data by several orders of magnitude in the first year alone. Photoproduction is specifically well suited to search for meson-gluon hybrids because the production cross-sections are higher for meson-gluon hybrids from photons, with the spins of the virtual quark-antiquark pair aligned, than from other sources such as pions, with the spins of the quark-antiquark pair anti-aligned. There are also other Hall D experiments proposed to look for physics beyond the Standard Model by studying Eta rare or forbidden decay channels such as eta to two neutral pions. The 12 GeV upgrade of the JLab accelerator and the complete physics program of Hall D will be presented.

ANALYSIS OF THE PION-NUCLEUS ELASTIC SCATTERING USING THE MICROSCOPIC OPTICAL POTENTIAL

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The pion-nucleus microscopic optical potential [1], defined by the pion-nucleon amplitude of scattering and by the density distribution function of a target nucleus, was applied for numerical solving the relativistic wave equation [2]. So, the elastic scattering differential cross sections were calculated and fitted to the experimental data of scattering of pions from the ^{28}Si, ^{58}Ni, and ^{58}Pb nuclei at T_{lab} = 291 MeV [3]. One can stress that doing so the relativistic and distortions effects in initial and final channels were accounted for automatically. As the result of such an analysis the best fit set of in-medium parameters of the pion-nucleon amplitude was established and compared with the corresponding parameters of the amplitude of scattering of pions on free nucleons.

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A MODELING OF THE PION-NUCLEUS MICROSCOPIC OPTICAL POTENTIAL AT ENERGIES OF 33-RESONANCE AND IN-MEDIUM EFFECT ON THE PION-NUCLEON AMPLITUDE OF SCATTERING

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Analysis is performed of differential cross sections of elastic scattering of pions on different nuclei at energies between 130 and 230 MeV. To this end the pion-nucleus microscopic optical potential (OP) [1] was constructed using the optical limit of a Glauber theory. Such an OP is defined by the corresponding target nucleus density distribution function and by the elementary πN-amplitude of scattering. Then the pion-nucleus cross sections were calculated by numerical solving the corresponding relativistic wave equation [2] with the above OPs. The three parameters of the πN scattering amplitude, total cross section, the ratio of real to imaginary part of the forward πN-amplitude, and the slope parameter, are firstly taken from existing experimental data on scattering of pions on free nucleons. As the next step these parameters were fitted to the data on the respective pion-nucleus cross sections [3],[4]. Thus, comparing the sets of "free" parameters to those obtained from pion-nuclear scattering data, one can estimate the "in-medium" effect on a pion surrounded by nuclear nucleons. The special procedure of the freely variation of parameters [5] was developed and applied to get the fast and effective χ^2 minimization process. A difference between the best fit values of the in-medium and free parameters of the πN scattering amplitude is discussed. Conclusions on the mechanism of scattering at the 33-resonance energies are made.

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HEAVY FLAVOUR PRODUCTION IN PP COLLISIONS AND INTRINSIC QUARK COMPONENTS IN PROTON

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The study of the forward heavy flavour hadron production can be a new unique source for estimation of intrinsic charm, bottom and strangeness contributions to the proton. We present a short review on a search for these quark components in the proton and illustrate a possibility to observe them in ep DIS and pp inelastic collisions at high energies. As for example, we present some predictions for the D-meson production in pp collisions made within the perturbative QCD including the intrinsic charm (IC) in the proton [1] that can be verified at the LHC. By the calculations we used the parton distribution function of type CTEQ66c with the IC probability about 3.5 that describes rather satisfactorily the ep DIS [2]. Figure 1 shows that the IC contribution for the single D^0-meson production can be sizable, it is about 100 % at large pseudo-rapidities $3 \leq \eta \leq 4.5$ and large transverse momenta $10 \leq p_t \leq 25$ GeV/c. The search for the intrinsic strangeness in p-p collisions at the energies of LHC, CBM, HADES and NICA experiments is also discussed.

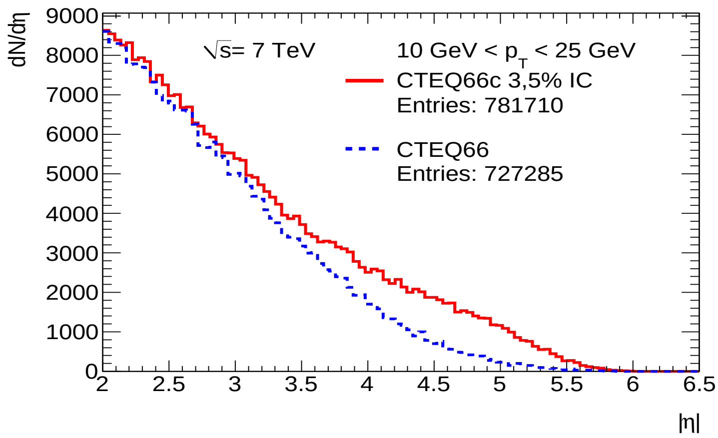

Figure 5: The $D + \bar{D}_0$ distributions over the pseudo-rapidity η in $pp \to (D_0 + \bar{D}_0)X$ at $\sqrt{s} = 7$ TeV and $10 \leq p_t \leq 25$ GeV/c. The solid line corresponds to the IC inclusion with the probability about 3.5%; the dashed curve corresponds to the calculations ignoring the IC contribution in proton.

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PAIR CORRELATIONS OF INTERNAL QUANTUM NUMBERS AND ENTANGLED TWO-PARTICLE STATES

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The properties of nonfactorizable (entangled) two-particle quantum states are discussed . The study of spin correlations of two identical particles with spin 1/2 at low relative momenta is performed. The angular correlations of decay directions for two unstable particles, connected with the correlations of their spin quantum numbers, are considered. It is shown that, for nonfactorizable two-particle states, the "classical" incoherence inequalities for the correlation tensor components [1], being analogous to the Bell inequalities, may be violated .

Concretely, the spin correlations and angular correlations for the systems $(\mu^+\mu^-)$, $(\tau^+\tau^-)$, produced in the reactions $e^+e^- \to \mu^+\mu^-$, $e^+e^- \to \tau^+\tau^-$ [2], for the systems of final leptons in the processes $\gamma\gamma \to e^+e^-$, $\mu^+\mu^-$, $\tau^+\tau^-$[3], and also for the $\Lambda\Lambda$ and $\Lambda\bar{\Lambda}$ systems generated in relativistic heavy-ion collisions [4], have been analyzed . It is noted that the sharp change of the correlation tensor for the $\Lambda\bar{\Lambda}$ pair with the increase of energy may testify to the passage through the "mixed phase" [4].

Some other correlations of internal quantum numbers, being analogous in structure and having the strongly pronounced quantum character, have been also considered : spin correlations in the $(p, {}^3He)$ system formed in the reaction $\pi^+ + {}^4He \to p + {}^3He$ [5], correlations of linear and circular polarizations of two γ quanta [6], and correlations at the registration of two neutral K mesons generated in inclusive multiparticle processes with the strangeness conservation [7] (and also pairs of neutral charmed and beauty mesons $D^0\bar{D}^0, B^0\bar{B}^0, B_s^0\bar{B}_s^0$ [8]) .

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BARYON STRUCTURE IN AdS/QCD

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We develop the soft-wall model (bottom-down AdS/QCD approach) for description of baryons [1]-[4]. As application we present a detailed analysis of nucleon electromagnetic and axial form factors in a holographic soft-wall model [2]. This approach is based on an action which describes hadrons with broken conformal invariance and incorporates confinement through the presence of a background dilaton field [1]-[6]. For $N_c = 3$ we describe the nucleon structure in a superposition of a three valence quark state with high Fock states including an adjustable number of partons (quarks, antiquarks and gluons) via studying the dynamics of 5D fermion fields of different scaling dimension in anti-de Sitter (ADS) space. According to the gauge/gravity duality the 5D fermion fields of different scaling dimension correspond to the Fock state components with a specific number of partons. In the present application we restrict to the contribution of 3, 4 and 5 parton components in the nucleon Fock state. With a minimal number of free parameters (dilaton scale parameter, mixing parameters of partial contributions of Fock states, coupling constants in the effective Lagrangian) we achieve a reasonable agreement with data for the nucleon form factors.

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START AND TRIGGER DETECTOR T0 OF THE ALICE EXPERIMENT

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One of the most important part of the ALICE installation is the T0 detector for the trigger and start system for time of flight.
The short description and performance of this detector will be presented. High time resolution was obtained for for pp interactions about 40 ps and 20ps for heavy ions.
The detector is used for online luminosity monitoring with fast feedback to accelerator team. T0 detector supplies five different trigger signals for background rejection and physics selections. The detector shows very good performance and stable work at high interaction rate up to 400 KHz.

HYPERFRAGMENTS FROM LIGHT p−SHELL NUCLEI

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The observation of the heavy hyper Hydrogen ${}^{6}_{\Lambda}$H [1] revived interest in identification of hyperfragments - products of the strong decay of a primary hypernuclei.

The registration of hypernuclei ${}^{6}_{\Lambda}$H and ${}^{8}_{\Lambda}$H was already put on the list of tasks for Nuclutron [2]. Recently, new experiment has been proposed for JLab [3].

In our contribution we compare different methods of the hyperfragments production based on the three contemporary experimental activities. For modelling possibilities of a hyperfragment production the translation invariant shell model is used. Only light p-shell nuclei are analyzed.

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RENORMDYNAMICS, COUPLING CONSTANT UNIFICATION AND UNIVERSAL PROPERTIES OF THE MULTIPARTICLE PRODUCTION

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The main properties of the Renormdynamics in the case of the QCD are defined. The coupling constant unification beyond the SM and universal properties of the high energy multiparticle production processes are considered [1].

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ASYMPTOTIC PROPERTIES OF THE NUCLEAR MATTER

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On the basis of the approach offered by A.M.Baldin and A.I.Malakhov [1], predictions of the yield ratio of the antiparticles to particles in the heavy ion collisions from low energy to asymptotically high energy are made. Comparison of the received predictions with LHC experimental data is presented. There is a good agreement between predictions and experimental data up to LHC energy.

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PROMPT PHOTON AND ASSOCIATED HEAVY QUARK PRODUCTION IN THE KT-FACTORIZATION APPROACH

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In the framework of the kt-factorization approach, the production of prompt photons in association with a heavy (charm or beauty) quarks at high energies is studied. The consideration is based on the $O(\alpha\alpha_s^2)$ off-shell amplitudes of gluon-gluon fusion and the small x approximation for quark-(anti)quark interaction subprocesses. The unintegrated parton densities in a proton are determined using the Kimber-Martin-Ryskin prescription. The analysis covers the total and differential cross sections and extends to specific angular correlations between the produced prompt photons and muons originating from the semileptonic decays of associated heavy quarks. Theoretical uncertainties of our evaluations are studied and comparison with the results of standard NLO pQCD calculations is performed. Our numerical predictions are compared with the recent experimental data taken by the D0 and CDF collaborations at the Tevatron. Finally, we extend our results to LHC energies.

DETERMINATION OF FAST NEUTRON SPECTRUM BY A DEFORMATION OF THE REFERENCE SPECTRUM EXPANDED ON LEGENDRE POLYNOMIALS ACCORDING TO REACTION RATES IN THRESHOLD DETECTORS

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Software for neutron spectra unfolding use experimentally determined reaction rates in threshold detectors and energy dependence reaction cross-section in a range from 0.025 eV to 20 MeV (see, for example, [1]) For high neutrons energies (up to 100 MeV and more) the information on energy dependence of reaction cross-section is not sufficient.

In the present work the method of spectra unfolding for fast neutrons in a range 0.2 … 100 MeV, based on use of the modified method of effective threshold cross-sections and a method of deformation of a reference spectrum expanded on Legendre polynomials.

In traditional approach a deformation applied to find of a required differential spectrum *φ(E)*. Authors propose to use deforming function in the form of expansion on Legendre polynomials for a finding of integrated spectrum *F(E)*. It is shown that as *F(E)* is monotonously decreasing function aspiring to zero at approach to the maximum energy of a spectrum. This function can be presented shorter number of required factors a_m of a polynomial. In the developed program the reactions cross-sections was taken from library [2], for those reactions which do not have cross-sections above 20 MeV results from [3] are used up to 150 MeV. The account of such "tails" allows calculating more precisely effective cross section, especially for the reactions having high thresholds.

The developed program was applied to fast neutron spectra unfolding in Quinta facility irradiated by deuterons in the energy range 1 - 8 GeV (JINR, LHE, Dubna)

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FUZZY TOPOLOGY, QUANTIZATION AND LONG-DISTANCE GAUGE FIELDS

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Dodson-Zeeman fuzzy topology (FT) is studied as possible quantization formalism [1]. FT elements are fuzzy points (FP) $\{a_i\}$, beside standard orderimg relation $a_j \leq a_k$, they admit also the incomparability relation (IR) between them: $a_j \sim a_k$, so $\{a_i\}$ set A^P is partial-ordered set (Poset)[2]. For 1-dimensional geometry Universe is supposedly Poset $U = A^P \cup X$, where X - standard coordinate axe R^1, so that $a_j \sim x_b$ permitted for some $x_b \in X$. a_i properties are detalized relative to X by the introduction of fuzzy weight $w_i(x) \geq 0$ with norm $||w|| = 1$ [3]. If $w_i(x) \neq 0$ on some X interval $\{x_c, x_d\}$, then a_i coordinate relative to X is principally uncertain [2]. It supposed that FP $a_i(t) \in A^P$ describes massive particle m_i, its fuzzy state $\varphi_i(t)$ evolves relative to X. It's shown that other φ free parameter is w flow velocity $\vec{v}(x)$, so that in $x-$representation: $\varphi(x) = \sqrt{w}e^{i\alpha}$ where $\alpha(x)$ defined via: $grad(\alpha) = m\vec{v}(x)$. Assuming space-time shift invariance, it follows that $\varphi(t)$ evolution obeys to free Schroedinger equation [4, 5], it fulfilled also for 3-dimensional case. In relativistic case free m_i evolution corresponds to Dirac equation with spin $\frac{1}{2}$. Massive particle's interactions in infrared limit are analyzed, it's shown that FT demands them to be gauge invariant. From that it proved that the interactions of fermion muliplets are performed by corresponding Yang-Mills fields [4, 5].

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DOUBLE CUMULATIVE PHOTON SPECTRA AT MID RAPIDITY AND HIGH PT IN C+BE COLLISIONS AT 2.0 AND 3.2 AGeV

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The photon spectra in central rapidity region were measured in C+Be collisions at beam energy 2.0 and 3.2 AGeV. The experiment was done in ITEP accelerator. The FLINT setup was wide acceptance (35^0-73^0 in lab. system) electromagnetic calorimeter. The energy range of measured photons was from 1 to 3 GeV. It was shown that most photons produced in the flucton-flucton interaction and it was up to 6 nucleons involved into interaction. Such kind of the interaction could be called "double cumulative" interaction.

QCD IN INFRARED REGION AND SPONTANEOUS BREAKING OF THE CHIRAL SYMMETRY

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1. QCD in Infrared Region.
2. Quasiclassical QCD Vacuum.
3. Spontaneous Breaking of the Chiral Symmetry.
4. Instanton Vacuum Model.
5. Chiral Lagrangian.
6. Light quarks in the instanton vacuum.
7. Dynamical quark mass.
8. Quark condensate.
9. Vacuum magnetic susceptibility.
10. Pion physics: F_π, M_π, and l_3, l_4, $m_u - m_d$ and h_3 , l_7.

NANOSYSTEMS: PHYSICS, APPLICATIONS, PERSPECTIVES

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A brief review of some basic nanosystems is proposed. Atomic clusters, quantum dots, carbon nanosystems, quantum transport (including spintronics), topological insulators, optical lattices, quantum optimal control, and Bose-Einstein condensates are covered. The main points of interest for fundamental physics and practical applications are sketched. Possible crossovers with nuclear physics are discussed.

QUARK AND HADRON DEGREES OF FREEDOM IN THE ROPER RESONANCE ELECTROPRODUCTION

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We suggested [1] a two-component model of the lightest nucleon resonance $R = N_{1/2^+}(1440)$ as a combined state of the quark configuration $sp^2[3]_X$ and the hadron molecule component $N + \sigma$. This approach allows to describe with reasonable accuracy the recent CLAS electroproduction data [2] at low- and moderate values of Q^2 with $0 \leq Q^2 \lesssim 1.5 - 2$ GeV^2. In the model the $R \to N + (\pi\pi)^{I=0}_{Swave}$ transition process is interpreted as the decay of a virtual σ meson in the $N + \sigma$ component. The calculated decay width $\Gamma_{R\to N\sigma(\pi\pi)}$ correlates well with the PDG value and the recent CB-ELSA and A2-TAPS data [3]. The weight ≈ 0.36 of the $N + \sigma$ component in the Roper is compatible with the CLAS data at low and moderate Q^2. This weight is also compatible with the value of the helicity amplitude $A_{1/2}$ at the real photon point.

However, our evaluations have shown that at low Q^2 the contribution of the pion cloud to the amplitude $A_{1/2}$ can be considerable (see e.g. [4]). For example, this is evident from comparison of our results with the data in low-Q^2 region. The discrepancy of our results and the CLAS data is about 1 – 1.5 experimental error bars. Still, this discrepancy is considerably smaller than in the case of previous quark models: the valence quark covariant spectator model [5]) or the LF models [4] in the same region of $Q^2 \lesssim 1$ GeV$^2/c^2$.

In this work we tried to show that the description of transition amplitudes in terms of parton-like models, which are very good at high Q^2, can be naturally transformed into a description in terms of the 'soft' vector meson cloud at low Q^2. This smooth transition is achieved by 'switching on' a non-zero radius of the intermediate vector meson. The vector meson V of finite size generates a non-local Vqq interaction when it is considered in terms of the $^3P_0$ model. This weakens the effect of the orthogonality of the spatial R and N wave functions in the low-Q^2 transition matrix element $N + \gamma^*_T \to R$ (the amplitude $A_{1/2}$ near the real photon point). A relativistic generalization of our model is in progress.

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RECENT RESULTS FROM PHENIX EXPERIMENT AT RHIC

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We will present the most recent results on nucleus-nucleus collisions at Relativistic Heavy Ion Collider obtained by the PHENIX collaboration. The talk will include new high precision d+Au data with a goal to probe initial state effects in direct photons, jet reconstruction, psi-prime production. Collision geometry control in Au+Au, U+U and Cu+Au interactions allows to probe hot dense matter by measurements of azimuthal angle parameters V1 and V2 . For the first time J/psi mesons have been measured in asymmetric Cu+Au collisions. PHENIX gets new results on pi0 suppression, direct photon production and its flow, gamma-hadron correlation. Beam energy scan allows to explore the QCD phase diagram and to estimate beam energy dependence of hadron fractional momentum loss. New high statistics results will be presented for electron suppression from heavy charm and bottom quark decays.

INVESTIGATION OF THE POSSIBILITY TO USE ION BEAMS FOR ADS THROUGH SIMULATION IN GEANT4

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Proton and ion beams with the initial energy between 0.2 AGeV and 10 AGeV were analyzed with respect to the neutron production in different targets, the number and spatial distribution of fission acts and the energy deposited in uranium targets. In this energy range two models for the hadronic inelastic interaction are suitable: bertini cascade and binary cascade. In thin and medium thickness targets both models produce results in good agreement with the experimental data. In very thick targets the use of binary cascade gives neutron production about two times lower than the bertini cascade and the experimental data. For this reason the last model was chosen for the modeling of the hadronic inelastic interaction. In large uranium target the total number of fission acts (the energy deposited) per incident particle, reported to the energy spent to accelerate the particle and to the total number of fission acts (the energy deposited) per incident proton with the same energy per nucleon increases with the mass number of ion. Such dependence for the number of fission acts shows a quick rise for ions until Fe, followed by a slower increase. The simulations performed show that from the point of view of the energetic balance (neglecting the problem of a suitable beam intensity) it seems more useful to accelerate at the same energy per nucleon, ions with mass number between Ca and Fe, than protons.

NUCLEAR FIRST ORDER PHASE TRANSITION IN HEAVY-ION REACTIONS AT INTERMEDIATE ENERGIES

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The nuclear first order phase transition of the liquid-gas type associated with the Gibbs free energy and the first order phase transition associated with the Helmholtz free energy were studied. The main thermodynamical properties of the first order phase transition associated with the Gibbs free energy were explored in the framework of the relativistic mean-field (RMF) hadronic model. But the first order phase transition associated with the Helmholtz free energy was investigated in the model of the decay of nuclei into nucleons, which is a limiting case of the statistical multifragmentation model. For the first order phase transition of the RMF model the thermodynamical potential G is the piecewise smooth function and its first order partial derivatives with respect to variables of state are the piecewise continuous functions. The energy in the caloric curve is discontinuous in the isobaric and the grand canonical ensembles at fixed values of the pressure and the chemical potential, respectively, and it is continuous, i.e. it has no plateau, in the canonical and microcanonical ensembles at fixed values of baryon density, while the baryon density in the isotherms is discontinuous in the isobaric and the canonical ensembles at fixed values of the temperature. For the nuclear first order phase transition associated with the Helmholtz free energy the thermodynamic potential F is a piecewise smooth function and its first order partial derivatives with respect to variables of state are piecewise continuous functions. At the points of phase transition, the energy in the caloric curve is discontinuous at the constant temperature and fixed values of the specific volume, while the pressure and the chemical potential in the equations of state are discontinuous at the constant specific volume and fixed values of the temperature.

RELATIVISTIC CORRECTION TO THE FIRST MOMENT OF THE SPIN-DEPENDENT STRUCTURE FUNCTION OF THE DEUTERON $\Gamma_1^d(Q^2)$ IN THE LIGHT-CONE FORMALISM

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Abstract

This article calls attention to the estimation of the relativistic correction to the mean proton helicity in the deuteron by way of application of available modern realistic deuteron wave functions. A receipt has been proposed for the consistent calculation of relativistic nuclear correction to the first moment of the spin-dependent structure function of the deuteron. Relativistic correction induced change in the Bjorken sum rule has been discussed.

If the transverse momentum of a quark is negligible compared to its longitudinal momentum in the deep inelastic scattering of leptons on protons at high energies, the 4-momentum of the quark can be represented in the form $x_N p_\mu$, where $x_N = Q^2/2pq$ $(0 < x_N < 1)$ is the Bjorken dimensionless scaling variable for the nucleon, p_μ is the 4-momentum of the nucleon, q_μ is the 4-momentum transferred by the virtual photon, and $Q^2 = -q^2$. Furthermore, if the 4-momentum of the quark is represented in the form $x_d P_\mu$, where $x_d = Q^2/2Pq$ and P_μ is the 4-momentum of the deuteron, then $p_\mu = (x_d/x_N)P_\mu$, $p_+ = (1/\sqrt{2})(p_0 + p_3) = (x_d/x_N)P_+ = zP_+$, $z = x_d/x_N$ [1].

The spin structure function of the nucleon $g_1^N(x_N, Q^2)$ can be represented in the form of the half-sum of the spin structure functions of the proton and neutron:

$$g_1^N(x_N, Q^2) = \frac{1}{2}\left[g_1^p(x_N, Q^2) + g_1^n(x_N, Q^2)\right]. \tag{11}$$

The first moment of the spin structure function of the deuteron is

$$\Gamma_1^d(Q^2) = \int_0^1 g_1^d(x_d, Q^2)dx_d. \tag{12}$$

Expression for the first moment of the spin structure function of the deuteron can be separated into the nonrelativistic part and relativistic correction Δ_{rel} as [1]

$$\Gamma_1^d(Q^2) =< \nu_p > \Gamma_1^N(Q^2) = \left(1 - \frac{3}{2}w_D\right)\Gamma_1^N(Q^2) + \Delta_{rel}\Gamma_1^N(Q^2), \tag{13}$$

where first moment of the spin structure function of the nucleon

$$\Gamma_1^N(Q^2) = \int_0^1 g_1^N(x_N, Q^2)dx_N, \tag{14}$$

and

$$< \nu_p >= 1 - \frac{3}{2} w_D + \Delta_{rel}, \tag{15}$$

w_D is the probability of the D state in the deuteron.

The experimental values of the first moments of the spin structure functions of the proton Γ_1^p and neutron Γ_1^n at $Q^2 = 5\,\mathrm{GeV}^2$ obtained by the E155 collaboration by analyzing all available data are as follows [3]:

$$\Gamma_1^p = 0,118 \pm 0,004\,(\text{stat.}) \pm 0,007\,(\text{sist.}), \tag{16}$$
$$\Gamma_1^n = -0,058 \pm 0,005\,(\text{stat.}) \pm 0,008\,(\text{sist.}). \tag{17}$$

The experimental value for Γ_1^d is

$$\Gamma_1^d = 0,028 \pm 0,004\,(\text{stat.}) \pm 0,005\,(\text{sist.}). \tag{18}$$

The Bjorken and Ellis-Jaffe sum rules are theoretical relations of the first moments for the proton and neutron to the fundamental weak coupling constants. The test of the Bjorken sum rule for $Q^2 = 5\,\mathrm{GeV}^2$ with the experimental data [3] give $\Gamma_1^p - \Gamma_1^n = 0,176 \pm 0,003\,(\text{stat.}) \pm 0,007\,(\text{sist.})$. The first moment of the spin structure function of the neutron extracted from the measured first moments of the spin structure functions of the deuteron $\Gamma_1^D|_{exp}$ and proton $\Gamma_1^p|_{exp}$ including the relativistic correction is represented in the form

$$\Gamma_1^n(Q^2) = \frac{2\Gamma_1^d(Q^2)|_{exp}}{< \nu_p >} - \Gamma_1^p(Q^2)|_{exp}. \tag{19}$$

At $Q^2 = 5\,\mathrm{GeV}^2$, $\Gamma_1^n(Q^2) = -0.05621$. The Bjorken sum at $Q^2 = 5\,\mathrm{GeV}^2$ gives $\Gamma_1^p - \Gamma_1^n = 0.17421$. There are several different parameterizations for the spin structure function of the nucleon $g_1^N(x, Q^2)$. In this work, the parameterization of parton distributions LSS2006 [4] is used. The results were obtained with the Bonn wave function of the deuteron (w_D=0,0425) [5].

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CONDENSATE CONFORMAL SYMMETRY BREAKING

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Low energy QCD, Higgs particle mass value, and new cosmological data are considered as the evidences of the condensate conformal symmetry breaking by means of normal ordering of field operators in QCD, SM, and GR.

DEVELOPMENT OF DYNAMIC MODEL FOR SIMULATION OF NUCLEAR SPALLATION

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Nuclear spallation is a challenging task for theoretical models. Quantum Molecular Dynamic (QMD) model was successful for calculations of isotopes generation for energy less than 0. 3 GeV, was presented in [1, 2]. The aim of this study is development of Ultra Relativistic Quantum Molecular Dynamic (UrQMD) model for calculations of isotopes generation for higher incident energies. Calculations are divided into three stages. On the first stage, realized in the framework of the UrQMD, time evolution of spatial distributions of nucleons and mesons (pions, kaons, etc) is traced. On the next step the nuclear fragments are shaped from nucleons and clusters, and their kinetic energies, masses and binding energies are calculated. On the last stage of the reaction the decay of the excited fragments to smaller ones are calculated. The nuclear fragments are generated via dynamical forces between nucleons during the evolution of the interacting system. This dynamical model is analyzed in comparison with the model of statistical (multi)fragmentation, namely, the cascade model including evaporation and multifragmentation, simulated in the framework of percolation model [3]. Calculations with the usage of both models were performed for the interaction of the proton with iron nucleus for proton energies from 0.3 GeV to 1.5 GeV. Mass distribution of fragments is compared with the experimental data obtained at GSI [4].

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STUDIES OF ETA-MESIC NUCLEI AT THE LPI ELECTRON SYNCHROTRON

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New data on photoproduction of eta-mesic nuclei on ^{12}C have been collected at the LPI electron synchrotron using a bremsstrahlung photon beam of $E_{\gamma max}$ = 850 MeV. A two-arm time-of flight spectrometer setup was used to detect correlated $\pi^{+}n$ and *pn* pairs from annihilation of stopped eta-mesons in the nuclear matter and to measure their velocity distributions.

Data analysis was performed using an intra nuclear cascade model in the GEANT-3 framework in order to take into account properties of the setup and physical background. Separation between charged pions and protons has been done using information on velocity and range of the particles.

The obtained data show a presence of emitted correlated *pn* pairs with velocities corresponding to the kinematics of the near-threshold reaction of two-nucleon annihilation of the η-meson, $\eta+p+n \rightarrow p+n$. Assuming that such pairs are produced through a formation of quasi-bound η-nucleus states (eta-mesic nuclei), the cross section of eta-mesic nucleus formation was estimated.

SEARCH FOR DOUBLE PARTONS AT CDF

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A search for double parton hard scattering has been performed by looking in the transverse region in φ relative to the highest E_T jet or Z boson in the event. A 'trigger' is used to create a pair of soft jets in the transverse region. The trigger is checked by applying it to events with two distinct vertices, one having the high E_T hard scatter, and the second being minimum bias. The trigger yields back to back jet pairs in the transverse region in φ in 1/1000 of all second vertices. The results of applying this trigger to single vertex high E_T jets and $Z \to \mu\mu$ will be reported.

HOMOGENEOUS BALITSKY-KOVCHEGOV HIERARCHY AND REGGEON FIELD THEORY

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The low dimensional field theory corresponding to Balitsky-Kovchegov hierarchy of equations with homogeneous initial conditions is derived using two approaches. The first approach is based on stochastic Balitsky-Kovchegov equation and uses Martin-Siggia-Rose auxiliary response fields. The second one is based on dimensional reduction of BFKL pomeron field theory action functional. Constructed field field theory has a structure of Reggeon Field Theory which is much simpler that BFKL pomeron field theory.

It is shown that conventional non-stochastic Balitsky-Kovchegov equation is a classical field equations of this field theory with specific boundary conditions. Since BFKL pomeron field theory contains both target and projectile currents it is argued that in case of scattering different class of boundary conditions should be used.

Using the boundary conditions that directly respect target-projectile duality different class of evolution equations is constructed. Analogous to non-stochastic Balitsky-Kovchegov equation it also contains additional terms which represents pomeron merging. These evolution equations allows consistent definition of various experiment related quantities such as inclusive and exclusive cross-section in case of scattering of spatially homogeneous target and projectile.

The work is supported by RFBR grant 11-02-01395-a.

KAON FEMTOSCOPY CORRELATIONS IN Pb–Pb COLLISIONS AT $\sqrt{s_{\rm NN}}$ =2.76 TeV FROM THE ALICE EXPERIMENT AT LHC

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We present results of kaon correlation analysis in Pb–Pb collisions at 2.76 TeV. The charged $K^{\pm}K^{\pm}$ (neutral $K_s^0K_s^0$) kaon correlations are analyzed in three centrality and seven (four) transverse momentum k_T bins. The femtoscopic source parameters, namely the invariant radius $R_{\rm inv}$ and the correlation strength λ are extracted and coincide within experimental errors for the considered particle types. The obtained radii decrease with increasing k_T and for more peripheral collisions. This is understood as a manifestation of the collective behavior of matter and is in accordance with predictions of hydrodynamic models. The transverse mass m_T scaling of radii, present in these models, is verified by comparing $R_{\rm inv}$ obtained for pions, kaons, and protons.

SCATTERING OF K(+) MESON FROM Ca(40) NUCLEUS AT SOME INTERMEDIATE ENERGIES

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The Scattering of K(+) meson from Ca(40) at incident kaon momenta in the range 488-800 MeV/c, has been studied . Elastic differential and total cross sections are calculated in the framework of a relativistic optical potential constructed on the one-body-exchange (OBE) form and the Julich parametrization of the potential is used where the applied potential has two types of these parametrizations based on four exchanged mesons. The associated generalized Yukawa (GY) meson function used in Calculations.

A NEW APPROACH TO THE THEORY OF ELECTROMAGNETIC INTERACTIONS WITH BOUND SYSTEMS: CALCULATIONS OF DEUTERON MAGNETIC AND QUADRUPOLE MOMENTS

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We would like to show one more application of the clothed particle representation (CPR) (in particular, aimed at investigation of the e-d scattering [1, 2]. It is the case, where one has to deal with the matrix elements $\langle \vec{P}', M'|J^{\mu}(0)|\vec{P}=0, M\rangle$ (to be definite in the lab. frame). Here the operator $J^{\mu}(0)$ is the Nöther current density $J^{\mu}(x)$ at the point $x=0$, sandwiched between the eigenstates of a "strong" field Hamiltonian H, viz., the deuteron states $|\vec{P}=0, M\rangle$ ($|\vec{P}'=\vec{q}, M'\rangle$) in the rest (the frame moving with the velocity $\vec{v}=\vec{q}/m_d$, where $\vec{q}$ the momentum transfer). These states meet the eigenstate equation $P^{\mu}|\vec{P}, M\rangle = P^{\mu}_d|\vec{P}, M\rangle$, with $P^{\mu}_d=(E_d, \vec{P})$, $E_d=\sqrt{\vec{P}^2+m_d^2}$, $m_d=m_p+m_n-\varepsilon_d$, the deuteron binding energy $\varepsilon_d>0$ and eigenvalues $M=(\pm 1, 0)$ of the third component of the total (field) angular-momentum operator in the deuteron center-of-mass (details in [3]).

In the subspace of the two-clothed-nucleon states with the Hamiltonian $P^0=K_F+K_I$ and the boost operator $\mathbf{B}=\mathbf{B}_F+\mathbf{B}_I$, where free parts K_F and $\mathbf{B}_F$ are $\sim b_c^{\dagger}b_c$ and interactions K_I and $\mathbf{B}_I$ are $\sim b_c^{\dagger}b_c^{\dagger}b_c b_c$, the deuteron eigenstate acquires the form

$$|\mathbf{P}, M\rangle = \int d\mathbf{p}_1 \int d\mathbf{p}_2 C_M([\mathbf{P}]; \mathbf{p}_1\mu_1; \mathbf{p}_2\mu_2) b_c^{\dagger}(\mathbf{p}_1\mu_1) b_c^{\dagger}(\mathbf{p}_2\mu_2)|\Omega\rangle.$$

When finding the C-coefficients we use the relation $|\vec{q}, M\rangle = \exp[i\vec{\beta}\vec{B}(\alpha_c)]|\mathbf{0}, M\rangle$, with $\vec{\beta}=\beta\vec{n}$, $\vec{n}=\vec{n}/n$ and $\tanh\beta=v$, that takes place owing to the property $\exp(i\vec{\beta}\mathbf{B})P^{\mu}\exp(-i\vec{\beta}\mathbf{B}) = P^{\nu}L^{\mu}_{\nu}(\vec{\beta})$, where $L(\vec{\beta})$ is the matrix of the corresponding Lorentz transformation. Moreover, unlike the Bethe-Salpeter (BS) formalism, where the matrix elements of interest can be evaluated in terms of the Mandelstam current sandwiched between the deuteron BS amplitudes, our departure point is the expansion in the R-commutators

$$J^{\mu}(0) = WJ^{\mu}_c(0)W^{\dagger} = J^{\mu}_c(0) + [R, J^{\mu}_c(0)] + \frac{1}{2}[R,[R, J^{\mu}_c(0)]] + ..., (*)$$

in which $J^{\mu}_c(0)$ is the initial current, where the bare operators $\{\alpha\}$ are replaced by the clothed ones $\{\alpha_c\}$ and $W=\exp R$ the correspoding UCT. In its turn, the operator being between the two-clothed-nucleon states contributes as $J^{\mu}(0) = J^{\mu}_{one-body} + J^{\mu}_{two-body}$, where the operator

$$J^{\mu}_{one-body} = \int d\mathbf{p}' d\mathbf{p} F^{\mu}_{p,n}(\mathbf{p}', \mathbf{p}) b_c^{\dagger}(\mathbf{p}) b_c(\mathbf{p})$$

with $F^{\mu}_{p,n}(\mathbf{p}', \mathbf{p}) = e\bar{u}(\mathbf{p}')F_1^{p,n}[(p'-p)^2]\gamma^{\mu} + i\sigma^{\mu\nu}(p'-p)_{\nu}F_2^{p,n}[(p'-p)^2]u(\mathbf{p})$ that describes the virtual photon interaction with the clothed proton (neutron). Its appearance follows from the observation, in which the primary Nöther current operator, being between the physical (clothed) states $|\Psi_N\rangle = b_c^\dagger|\Omega\rangle$, yields the usual on-mass-shell expression

$$\langle\Psi_{p,n}(\mathbf{p}')|J^\mu(0)|\Psi_{p,n}(\mathbf{p})\rangle = F^\mu_{p,n}(\mathbf{p}',\mathbf{p})$$

in terms of the Dirac and Pauli nucleon form factors. By keeping only the one-body contribution we arrive to certain off-energy-shell extrapolation of the so-called relativistic impulse approximation (RIA) in the theory of e.m. interactions with nuclei (bound systems).

Of course, the RIA results should be corrected including more complex mechanisms of e-d scattering, that are contained in

$$J^\mu_{two-body} = \int d\mathbf{p}_1' d\mathbf{p}_2' d\mathbf{p}_1 d\mathbf{p}_2 F^\mu_{MEC}(\mathbf{p}_1',\mathbf{p}_2';\mathbf{p}_1,\mathbf{p}_2) b_c^\dagger(\mathbf{p}_1') b_c^\dagger(\mathbf{p}_1') b_c(\mathbf{p}_1) b_c(\mathbf{p}_2).$$

Analytic (approximate) expressions for the coefficients F^μ_{MEC} stem from the R-commutators (beginning with the third one) in the expansion (*), which, first, belong to the class [2.2], as in operators K_I and $\mathbf{B}_I$, and, second, depend on even numbers of mesons involved. It requires a separate consideration aimed at finding a new family of meson exchange currents to be useful, as we hope, not only for describing the e-d scattering.

At last, one should note that, as before (see, e.g. [4]), we prefer to handle the explicitly gauge-independent (GI) representation of photonuclear reaction amplitudes with one-proton absorption or emission [5]. This representation is an extension of the Siegert theorem, in which, the amplitude of interest is expressed through the Fourier transforms of electric (magnetic) field strengths and the generalized electric $\mathbf{D}(\mathbf{q})$ (magnetic $\mathbf{M}(\mathbf{q})$) dipole moments of hadronic system. It allows us to retain the GI in the course of inevitably approximate calculations. It has turned out that the Cartesian electric (magnetic) moments of the distribution $J^0(x)$ ($\mathbf{J}(x)$) can be deduced from the MacLaurin series, respectively, of the longitudinal projection $\mathbf{q}\cdot\mathbf{D}(\mathbf{q})$ and the function $\mathbf{M}(\mathbf{q})$ itself in the vicinity of the point $\mathbf{q}=0$. In particular, we find the following formula

$$\mu_d = \frac{1}{2m_d}\langle\vec{0}; M'=1|\left[\vec{B}\times\vec{J}(0)\right]^z|\vec{0}; M=1\rangle$$

for the magnetic moment of the deuteron. Of course, we could present details of our calculations to compare them with the available ones and show the corresponding numerical results.

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LONGITUDINAL PROFILES, FLUCTUATIONS AND CORRELATIONS OF ELECTROMAGNETIC CASCADES PRODUCED BY 100-3500 MeV GAMMA QUANTA IN HEAVY AMORPHOUS MEDIA

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Presently in use is practically the simplest and rough description of the main features of electromagnetic cascades (ECs) created in heavy amorphous materials (DAMs) by high energy gamma quanta (GQ): longitudinal profiles (LPs) only and several integral formulas describing the longitudinal energy deposition in ECs as estimations of energy resolution of photodetectors (for example, [1,2]). So, it is commonly assumed that the longitudinal distributions of energy deposition (or profiles) of ECs initiated in DAMs can be approximated satisfactorily by a gamma type function (for example, [1,2]). Nevertheless, such a simple model is not too adequate, especially at large depths t and at the very beginning of the cascade [2]. Moreover, in dense materials it is of practical importance to know a reliable description of transverse development of ECs. Furthermore, since the longitudinal dimensions of ECs increase with primary photons energy $E_\gamma$as lnE_γ at dimensions of electromagnetic calorimeters limited, usually to 20-25 radiation lengths (r.l.), it is also important to have practical information about longitudinal and transverse fluctuations in ECs. Moreover, in order to reconstruct as far as possible the real ECs picture and so to estimate with acceptable accuracy the primary gamma quanta energy of particular interest are also correlations in longitudinal EC development. The knowledge of this kind of correlations is of prime importance for segmented gamma detectors.

In the work we study the average longitudinal profiles, fluctuations and correlations of ECs created in eight most popular dense amorphous media: liquid xenon, PWO, $CdWO_4$, GaAs, NaI, Pb, lead glass and BGO by gamma quanta of energy E_γ =100÷3500MeV at four different cut-off energies E_{co} of electrons (0.6, 1.2, 2.0 and 3.0 MeV). The fluctuations have been investigated as a distribution of the shower depth, up to which a part A of energy E_γ, so-called threshold energy (TE), was deposited. Estimated are also correlations in longitudinal energy deposition of ECs. The work has been performed using EGS4 [3] and GEANT modeling codes [4]. For every set of parameters: E_γ, E_{co} and material we modeled 20000 events (histories). The ultimate objective of this investigation is to obtain simple formulas describing average profiles and fluctuations in ECs suitable for practical applications. It should also be mentioned that the first computer simulation of ECs profiles have been performed by E.Longo and I.Sestili [5] by means of Monte Carlo based code and A. De Angelis [6] using GEANT3.11 code.

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THE PHOTON CLUSTER EXCITATION MECHANISM OF THE $e^{-}e^{+}$ PLASMA CREATED FROM THE VACUUM IN A STRONG ELECTROMAGNETIC FIELD

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Some features of the momentum distribution of the residual $e^{-}e^{+}$ pair plasma (EPPP) created from the vacuum in a strong laser field in the multiphoton domain $\gamma = 2\pi E_c \lambda_c / E_0 \lambda > 1$ (E_0 and λ are the field strength amplitude and wavelength of the external electric field) are investigated in the low density approximation to the nonperturbative kinetic approach (e.g., [1, 2]). The traditional multiphoton mechanism of EPPP excitations is examined in comparison with the new photon cluster mechanism found in [3], where a photon cluster is introduced as a system of identical photons that act as one photon having the total energy of this system. We analyze the role of the simplest elementary photon processes in the EPPP with and without the assistance of the photon clusters, as well as the case of large photon numbers. These calculations are intended to find simple estimations of the secondary processes associated with the dynamical Schwinger effect [4, 5, 6, 7].

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ON MANIFESTATION OF QUARK-HADRON DUALITY VIA THE ADLER D-FUNCTION

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To compare theoretical results and experimental data one often uses the concept of quark-hadron duality, which establishes a bridge between quarks and gluons, a language of theoreticians, and real measurements with hadrons performed by experimentalists. The idea quark-hadron duality was formulated in the paper by Poggio, Quinn, and Weinberg [1] as follows: Inclusive hadronic cross sections, once they are appropriately averaged over an energy interval, must approximately coincide with the corresponding quantities derived from the quark-gluon picture. It is clear that it will be most fruitful to connect measured quantities with “simplest” theoretical objects. Some single-argument functions which are directly connected with experimentally measured quantities can play the role of these objects.

In this talk we concentrate on physical quantities and functions connected with the Adler D-function [2]. This function defined in the Euclidean region for positive momentum, $Q^2 = -q^2 > 0$, is a smooth function without traces of the resonance structure. Therefore one might expect that use of the Adler function is useful and that it more precisely reflects the quark-hadron duality, than, for example, use of the smeared quantity, $R_\Delta(q^2)$, defined in the timelike region [1]. The D-function was studied in a number of papers (see [4] for more details).

The theoretical approach that we use here is based on the nonperturbative a-expansion method (see [3]) which leads to a new small expansion parameter. Even going into the infrared region of small momenta where the running coupling becomes large and the standard perturbative expansion fails, the nonperturbative expansion parameter remains small and the approach holds valid. It is important that this method supports the correct analytic properties of the Adler function. Using the D-function in the theoretical description, we found good agreement between our results and corresponding experimental data down to the lowest energy scale (that is not calculable within standard perturbative QCD) both for the timelike and Euclidean quantities. We investigate the reason of such good agreement and as a result we formulate a criterion which we call as the $R - D$ self-duality.

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MONTE CARLO SIMULATIONS OF NATURAL URANIUM SETUPS IRRADIATED WITH RELATIVISTIC DEUTERONS BY MEANS OF MCNPX CODE

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The collaboration Energy and Transmutation of Radioactive Waste has used different set-ups consisting of lead, uranium and graphite irradiated by relativistic protons and deuterons to study transmutation of radioactive materials by produced neutrons. Such studies are intended for providing important data serving for the construction of larger-scale Accelerator-Driven Systems. The most recent set-up named QUINTA, consisting of natural uranium target and lead blanket, was irradiated by deuteron beams in the energy range between 1 and 8 GeV in the last three accelerator runs at JINR Nuclotron in 2011 and 2012. Monte Carlo simulations of the target assembly QUINTA concerning overall neutron production as well as spatial and energy distribution of the neutron field inside the set-up have been made using the MCNPX code and they have been compared with experimental data obtained by activation method.

COMBINED ANALYSIS OF PROCESSES $\pi\pi \to \pi\pi, K\overline{K}, \eta\eta$ AND J/ψ DECAYS AND PARAMETERS OF SCALAR MESONS

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The coupled processes – the $\pi\pi$ scattering, $\pi\pi \to K\overline{K}$, $\pi\pi \to \eta\eta$ and $J/\psi \to \phi\pi\pi, \phi K\overline{K}$ – are considered in the 2- and 3-channel approaches for studying f_0-mesons. An applied model-independent method of analysis is based on analyticity and unitarity and uses an uniformization procedure [1]. It is shown [2] that the analysis of the only $\pi\pi$ scattering data gives an excellent description from the threshold to 1.89 GeV with the resonance parameters, being the same as the ones, indicated in the PDG tables as estimations, and with the $\pi\pi$-scattering length being in accordance with the ones gotten from the K_{e4} decay data, in the DIRAC experiment at CERN and also in the ChPT calculations. However, (1) the $\pi\pi \to K\overline{K}$ are not well described even qualitatively above 1.15 GeV when using the resonance parameters from the only $\pi\pi$ scattering analysis, and (2) in this case, the description of $\pi\pi$ background is unsatisfactory (pseudo-background arises). I.e., a combined analysis of $\pi\pi \to \pi\pi, K\overline{K}$ is needed, which also is carried out satisfactorily, curing flaws (1) and partly (2) and changing inevitably the resonance parameters. The remaining $\pi\pi$ pseudo-background, arising at the $\eta\eta$ threshold and clearly indicating that it is necessary to consider explicitly also the $\eta\eta$-threshold branch-point, vanishes in the 3-channel analysis of processes $\pi\pi \to \pi\pi, K\overline{K}, \eta\eta$ performed. Moreover, the consideration of left-hand branch-point at $s = 0$ in the uniformizing variable, except $\eta\eta$-threshold branch-point, solves partly a problem, that the wide-resonance parameters are strongly controlled by the non-resonant background. Some possible scenarios of the resonance representations on the Riemann surface of the S-matrix, which give the similar description of the above processes and, however, the quite different parameters of some resonances [1], is rejected [3] when enlarging the analysis with adding the data on decays $J/\psi \to \phi\pi\pi, \phi K\overline{K}$ from Mark III , DM2 and especially from BES. There are changed most considerably parameters of the $f_0(600)$ – now the obtained mass is in some accordance with prediction by S. Weinberg on the basis of mended symmetry. Some spectroscopic implications from results of the analysis are discussed.

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ANALYSIS OF POTENTIAL ADVANCED THORIUM BASED FUEL FOR EPR REACTOR

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Analysis of possible ways of reduction of radioactive wastes by transmutation of radioactive long-lived fission products such as ^{99}Tc, ^{129}I and ^{135}Cs and by burning up of transuranic nuclides implies that the reactor core should consist of three zones with fast, epithermal and thermal neutron spectra. High flux thermal neutron environment ($\sim 10^{16}$ n/cm$^2\cdot$s) is expected as the best way for the transmutation of most of the radioactive waste to stable or short-lived nuclides and for increasing the probability for fission such actinides as ^{237}Np and ^{238}Np.

Since we are not able to construct such a reactor core with the three zones and we are not able to reach such an intense thermal neutron flux ($\sim 10^{16}$ n/cm$^2\cdot$s) in terms of technical feasibility and in view of the inefficiency of actinides incineration for a low intensity thermal neutron flux, we focus our attention on the thorium-uranium fuel cycle as a prophylactic way of energy production where the radio-toxicity of the wastes is about three orders of magnitude smaller than in the case of classical PWR reactors.

^{232}Th is a better fertile material than ^{238}U in thermal reactors because of the three times higher thermal neutron absorption cross-section of ^{232}Th (7.4 barns) as compared to ^{238}U (2.7barns). Thus, conversion of ^{232}Th to ^{233}U is more efficient than that of ^{238}U to ^{239}Pu in thermal neutron spectrum.. The values of cross sections in brackets refer to the thermal neutrons.

While the uranium 238-plutonium 239 fuel cycle requires fast neutrons to be sustainable, the thorium 232-uranium 233 fuel cycle is sustainable with either thermal neutrons or fast neutrons.

As thorium based fuels have benefits in terms of radio-toxicity there are however challenges in terms of reprocessing the spent thorium based fuel. The database and experience of thorium fuels and thorium fuel cycles are very limited , as compared to UO_2 and $(U,Pu)O_2$ fuels, and need to be augmented before large investments are made for commercial utilization of thorium fuels and fuel cycles.

That is why, as the first step of studying the thorium application feasibility, once through thorium based fuel cycle analysis for energy production and radioactive waste transmutation was undertaken, which does not require the technically difficult reprocessing of the spent fuel.

The idea is to analyze the thorium based fuel application in the open cycle feasibility study in the existing light water reactors with minimal modifications in order to exploit them.

Preliminary analysis of thorium based fuel application in the EPR reactor have shown that once through thorium fuel cycle can be reached with difficulty. It is inferred that the ^{233}U concentration tends to saturation value which does not depend on power density while the kinetics of reaching the saturation value depends on it.

Monte Carlo methodology calculations for the contribution to the analysis of thorium based fuel application in the EPR reactor and in the accelerated driven systems (ADS) were used.

NEW CONSIDERATIONS OF PAIRING AND RESIDUAL NUCLEON INTERACTION IN ATOMIC NUCLEI AND INTERPRETATION OF PUZZLE AT LHC- SO-CALLED «RIDGE-EFFECT“ AND OF NEW SCENARIO OF THE SYNTHESIS OF P-NUCLEI IN UNIVERSE IN PRESENT TIME

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Pioneering consideration of the pairing interaction of nucleons in atomic nucleus was made in fundamental monograph [1] Authors of [1] – Laureates of Nobel Prize 1963 in physics, look on the table of the stable nuclei, see the new effect of the staggering of the nuclear binding energy,

$$E\,(Z,N) = Z\,m\,(^1H) + Nm(^1n) - m(Z, N), \qquad (1)$$

That is determination in the conformity with Einstein a priori postulat (in present time it it is the law).

The formula for determination of the pairing energy , for example, of two neutrons [2] is

$$P_{nn} = \{S_n\,(Z,N)- [S_n\,(Z,N+1)+ S_n\,(Z,N-1)/2\,\} \qquad (2\,) \quad \text{see in[2]}$$

From the article [3] we have the formula for determination the residual energy of interaction of the neutron and proton

$$R_{np} = [S_n\,(Z,N) - S_n\,(Z-1,N) = R_{pn} = (S_p\,(Z,N)- S_p(Z,N-1)] \qquad (3)$$

In the article [4} the author considered of the two-proton decay poblem, using isotopic quasi invariant (in the Russian edition) and isobaric quasi invariant (in the English edition).

In the present work we use consideration of the pair and the residual interactuons in the frame of the simplest string mechanism of SFrom the consideration of the spontaneous breaking supersimmetry :we have:$S_n(^2H)$- $S_p(^2H)$=0 (supersimmetry), $S_n(^3H)$- $S_p(^3He)$= 0,763, 76 keV, $S_n(^4He)$- $S_p(^4He)$= ,0,763, $S_n(^5He\,)$- $S_p(^5Li\,)$= 100,763, 76 $S_n(^6Li\,)$- $S_p(^6Li\,)$= 100,7 , $S_n(^7Li\,)$- $S_p(^7Be\,)$= 1664,74, $S_n(^8Be)$ - $S_p(^8Be)$=1644,24 , $S_n(^9Be)$ - $S_p(^9B)$ = 1850,7 , $S_n\,(^{10}B\,)$ -$S_p(^{10}B)$ =1950.4keV and so on up to terminal nucleus $S_n(^{100}Sn\,)$- $S_p(^{100}Sn\,)$=14850 keV.And it is the end.. .

We outstanded well argumented invariant for nuclear binding energy, from which we have for the confine state of nuclei, for example, $S_p\,(\,^2He\}$ = 5493,48 keV, $S_n\,(^2n)$ = 9257,23keV.

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WHAT DO FRACTALS LEARN US CONCERNING FUNDAMENTAL PARTICLE MASSES AND HADRON MASSES? CONCERNING ALSO DISINTEGRATION LIFE-TIMES?

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Fractals exist in many aspects of nature and are observed, when the relative value of an observable, depends only on a parameter, and not on the variable. Unlike the *continuous* scale invariance, the *discrete* scale invariance is observed when the exponent of the power law is complex, inducing log-periodic corrections to the scaling. Two properties are studied:

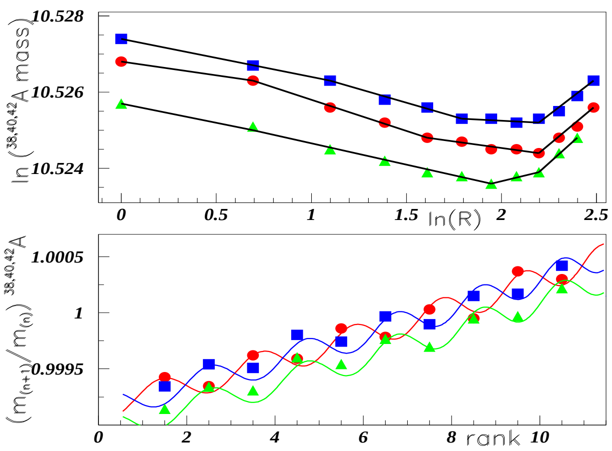
-the straights lines in the log(M) = log(rank), where M is the mass of a given species, and the rank denotes the successive values of the observable (here masses);

-the oscillations of the successive mass ratio distributions.

These properties are observed for the quark and lepton masses, and also a common figure implying quark, lepton and gauge boson masses.

They are also observed, up to rank ≈ 10 for all mesons and baryon species. The various parameters included in the fits of the mass ratio distributions, depend little on the studied species.

These fractal properties agree well with the variation of nuclei masses (isotopes or isotones). The figure shows the log-log distributions (after two shifts to clarify the figure), and the ratios of m_{n+1}/m_n masses, versus the rank, of three nuclei masses close to A = 40. Such agreement allows to tentatively predict some masses still not observed. The agreement with previous fractal properties, is worse for the spectra of nuclei energy levels. However the comparison between the excited level masses of all baryonic species, display noteworthy properties allowing again a tentative prediction of several unobserved masses.



Several other data verify fractal properties:

- life-times of nuclei following α radioactive decay chains,
- masses of series following or β^+ or β^- disintegrations,
- masses of several columns in the Mandeleiev table,
- narrow exotic hadronic masses,
- mass ratios between different baryonic or mesonic species
- PDG baryon/meson mass ratios,
-.......

In conclusion, many particle and nuclei properties obey to the fractal laws.

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PREPARATION OF EXPERIMENTS TO STUDY LIGHT NUCLEI STRUCTURE AT NUCLOTRON

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The results of preparation of experiments at extracted beam and internal target station at Nuclotron-JINR are reported. First extraction of the 3.42 AGeV carbon beam and of the 4 A*GeV deuteron beam at Nuclotron and their transportation to the experimental area and the measurements to study dp-elastic scattering, dW- and dAg- quasi-elastic scattering at internal target station at Nuclotron are performed.

NET CHARGE FLUCTUATIONS IN AA COLLISIONS IN A SIMPLE STRING-INSPIRED MODEL

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Net charge fluctuations have been proposed as a possible indicator of the formation of quark-gluon plasma in high-energy nucleus-nucleus collisions [1, 2]. The theoretical predictions of the value of the fluctuations [1, 2, 3] do not directly consist with the experimental results from RHIC [4]. At present the results extracted from ALICE experimental data have also rather ambiguous interpretation in the framework of existing models [5]. In this connection, we try to describe the experimental data in the framework of an alternative string-inspired model.

We introduce two effective sources of the hadron production. The first source emulates the mid-rapidity particle production from the decays of the strings. In the string model one has an approximate conservation of the charge locally in rapidity, so we assume this source emits N_{1+} positive and N_{1-} negative particles in the central rapidity interval Δy with the same mean values and variances, but due to "leakage" of the charge on the borders of the interval $N_{1+} \neq N_{1-}$ event-by-event. In string models the positive charge of initial nuclear protons is associated with their valence quarks and is concentrated at projectile and target rapidities. The transport of this charge into the mid-rapidity region Δy is the second cause of the deviation of the charge from zero in this region. To simulate this process we introduce the second source which produces only positive particles.

As a result the measure of the dynamical net charge fluctuations, ν_{dyn}, is expressed in terms of the model parameters. The parameters of the first (main) source are expressed through the parameters characterizing the individual string and their event-by-event distribution. The important feature of the model is that based on the results obtained in [6] we do not assume that the engaged fluctuations are poissonian.

The model calculations are compared with the experimental data on pseudorapidity dependence of ν_{dyn} from RHIC [4]. It is shown that under some assumptions the obtained results are consistent with the data.

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Z-SCALING: INCLUSIVE JET SPECTRA AT RHIC, TEVATRON AND LHC

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New experimental data on inclusive cross sections of jet production in *pp* collisions at the LHC obtained by the CMS, ATLAS and ALICE Collaborations are analyzed in the framework of z-scaling. Results are compared with data on spectra of jet production in $\bar{p}p$ collisions obtained by the CDF and D0 Collaborations at the Tevatron. Inclusive jet transverse momentum distributions in *pp* collisions measured by the STAR Collaboration at RHIC are compared with data on jet spectra obtained in the fixed target experiments at the FNAL. It is shown that self-similar features of jet cross sections manifested by the z-scaling give strong restriction on the scaling function $\psi(z)$ at high z. Energy and angular independence and asymptotic behavior of $\psi(z)$ are discussed. We conclude that the obtained results confirm self-similarity of jet production, fractality of hadron structure and locality of constituent interactions at small scales.

CHARMONIUM PRODUCTION IN HEAVY ION COLLISIONS

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The review of the experimental data on charmonium states production measured at the CERN SPS and in *p-p* and Pb-Pb collisions at LHC and comparison with the data obtained at the Brookhaven National Laboratory Relativistic Heavy Ion Collider RHIC is presented. The suppression of J/ψ production was suggested as a possible signal of quark gluon plasma formation in 1986 by Matsui and Satz. The anomalous suppression of J/ψ production at the CERN SPS was discovered in central Pb-Pb collisions by NA50 collaboration at 158 GeV. But the experimental and theoretical situation is more complicated. The effects of J/ψ suppression on cold nuclear matter and feed-down production from higher charmonium states are important in production of J/ψ at SPS energies. The PHENIX experiment at RHIC at $\sqrt{s}$ = 200 GeV shows that the J/ψ suppression at these energies is of the same order as the suppression at SPS energies for Pb-Pb. The models that include regeneration of J/ψ agree with the experimental results better. The study of charmonium production at LHC in *p-p* and Pb-Pb collisions shows the importance of regeneration process. The contribution of B-decay should be taken into account at LHC energy. The future high statistic measurements at LHC could investigate the properties of matter at high energy density and temperature. Also the energy intervals between SPS, RHIC and LHC are very important for study of the mechanism of quarkonium production and suppression, in order to investigate medium effects and conditions for Quark Gluon Plasma formation. If the proton and ion beams will be used at LHC with fixed targets, the energy interval between SPS and RICH in *p*-A and A-A collisions could be investigated. For 7 TeV proton beam we will get $\sqrt{s}$ = 114.6 GeV, for Pb beam at 2.75 TeV $\sqrt{s}$ = 71.8 GeV. This is unique possibility to clarify the mechanism of charmonium production and to separate two possibilities: i): hard production and suppression in QGP and/or hadronic dissociation or ii): hard production and secondary statistical production with $c\bar{c}$ recombination.

THE DEPENDENCE OF THE NUMBER OF POMERONS ON THE IMPACT PARAMETER AND THE LONG-RANGE RAPIDITY CORRELATIONS IN *pp* COLLISIONS

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The simple model which enables to take into account the effect of colour string fusion in *pp* interactions is suggested. We assume that the dependence of the average number of cut pomerons on the impact parameter in a non-diffractive (ND) *pp* collision is gaussian with the condition that we have at least one cut pomeron. We assume also that the event-by-event distribution of the number of cut pomerons around this average value is poissonian with the same condition. It is shown that after integration over impact parameter these two simple assumptions lead to the well known formula for the cross-section σ_n of n cut-pomeron exchange in a ND *pp* collision:

$$\sigma_n = \frac{\sigma}{nz}\left[1 - e^{-z}\sum_{k=0}^{n-1} z^k/k!\right] \,, \tag{20}$$

which was obtained in the quasi-eikonal [1, 2] and Regge [3] approaches. This enables to connect the parameters of our model with the parameters of the pomeron trajectory and its couplings to hadrons, through which the variables σ and z in the formula (20) are expressed.

The effects of the string fusion [4] on the multiparticle production are taken into account in the same way as it was done in the case of *AA* collisions [5, 6]. On the base of the model the Monte-Carlo algorithm is developed and the long-range correlation functions between multiplicities and between the average transverse momentum and the multiplicity in *pp* collisions at energies from SPS up to LHC are found.

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NEUTRON GENERATION BY RELATIVISTIC DEUTERONS IN THE URANIUM TARGET OF ASSEMBLY "QUINTA-M"

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The results of investigations of neutron generation by deuterons with energies of 2, 4, and 6 GeV in the uranium target of assembly "QUINTA-M" as well as deuterons with energies of 1, 4, and 8 GeV in the uranium target of assembly "QUINTA-M", surrounded by lead blanket are presented. Irradiations were carried out on the superconducting accelerator Nuclotron at the Laboratory of High Energy Physics, JINR, Dubna, Russia. The uranium target mass was 500 kg. To obtain the neutron spatial distribution in the volume of uranium target the activation detectors were used (uranium foils with a diameter of 8 mm and a height of 1 mm). After irradiation the gamma-spectra of activation detectors were measured by high-purity germanium semiconductor detectors. The spatial distributions of reaction rates of the radiative neutron capture by uranium $^{238}U(n,\gamma)$ and reactions of fission of uranium $^{238}U(n,f)$, as well as the distributions of spectral indices $\bar{\sigma}_{capt}^{238U} / \bar{\sigma}_{f}^{238U}$ were obtained. Based on the spatial distributions the integral values of plutonium production and the number of fissions in the uranium target were obtained. Analysis of the obtained results has shown that the lead blanket actually does not effect the number of fissions in the volume of uranium target of assembly "QUINTA-M", but increases the number of radiative capture reactions by more than 50%. The spectral index changes from the deuteron beam axis to the periphery of the uranium target from about 0.3 to 1 for QUINTA without lead blanket, and from 0.6 to 2 for QUINTA with lead blanket and does not depend on the energy of the primary beam in the range of 1–8 GeV. It was also shown that for a given sizes of uranium target for deuteron energies exceeding 1 GeV experimentally impossible to estimate the required sizes of the uranium target, satisfying her kvasi-infinity.

STUDIES OF DEUTERON AND NEUTRON CROSS-SECTIONS IMPORTANT FOR ADS

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The collaboration Energy and Transmutation of Radioactive Waste uses different setups consisting of lead, natural uranium and graphite irradiated by relativistic protons and deuterons to study transmutation of radioactive materials by produced neutrons. The activation samples are used to determine integral of proton or deuteron beams and also produced neutron flux in different places of experimental set-ups. Unfortunately almost no experimental cross-section data for deuterons with GeV energies are available. The similar situation is also for threshold (n,xn) reactions of neutrons with higher energies. Therefore we carried out series of experiments devoted to determination of deuteron reactions on copper during uranium target QUINTA irradiations by deuterons with energies from 1 GeV up to 8 GeV. The cross-sections of various threshold reactions were studied by means of different quasi-monoenergetic neutron sources with possible energies from 14 MeV up to 100 MeV.

As it was already mentioned, the cross-sections of deuteron reactions on copper were measured during several irradiations of big natural uranium target QUINTA. Values of deuteron cross-section for energies of 1, 2, 4, 6 and 8 GeV were obtained. The beam integral was determined mainly by aluminum foil and therefore accuracy of our values are correlated to known experimental values of deuteron reaction Al(α,3p,2n) cross section on aluminum. Only this reaction was measured. This and other sources of systematic uncertainties will be discussed in detail.

The cross-sections of many neutron reactions important for our activation detectors are missing. To improve situation we started a program of such cross-sections measurements by means of quasi-monoenergetic neutron sources. We use two such sources. The first facility is the neutron source based on the cyclotron at the Nuclear Physics Institute of ASCR, Řež. It provides neutron beams in the energy range from 14 MeV up to 35 MeV. The second neutron source is built around the cyclotron at TSL Uppsala. This facility provides neutron beam in the energy range from 14 MeV up to 200 MeV. We studied mainly cross-sections of neutron reactions on gold, aluminum, bismuth, cobalt and yttrium. We studied population of ground and isomeric states separately. The case of yttrium will be discussed in detail.

SUGGESTED INVESTIGATIONS CONCERNING UNRESOLVED EXPERIMENTAL OBSERVATIONS

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Evidence for unresolved experimental observations in nuclear interactions of high energy ions in thick targets is published. These unexplained phenomena concern reactions induced by secondary products originating from primary interactions with a hypothetical centre-of-mass energy per nucleon $E_{CM}/u > 150$ MeV. Below this centre-of-mass energy no unresolved experimental evidences are observed.

Before considering possible reasons for this new effect, it is suggested to define the experimental details and limitations for the unexplained observations more precisely. Several experimental studies are proposed:

- *Studies using a Cu target composed of 20 Cu disks of 1.0 cm thickness each and irradiated with ^{12}C ions of several energies in the range from 0.6 GeV/u ^{12}C to 1.8 GeV/u ^{12}C*

Yields of reaction products shall be measured in several 1.0 cm Cu disks together with the neutron production rates in the complete target, using radiochemical, nuclear track and counter techniques. This experiment shall give information about the onset of this phenomenon.

- *Re-measurement of unpublished preliminary results*

One should re-measure in a *quantitative* manner a very large (but unpublished) neutron fluence observed earlier in the irradiation of a 20 cm thick Cu target with 72 GeV ^{40}Ar. This experiment is overdue for some 25 years.

- *Studies on a 4 cm thick Cu target, composed of 20 Cu disks of 2 mm thickness each and irradiated with ^{12}C ions at maximum energy, if possible with 44 GeV ^{12}C ions [$E_{CM}/u = 488$ MeV].*

Yields of radioactive products shall be determined in all 0.2 cm Cu disks with radiochemical methods. Of particular interest will be the comparison of the intensity variation in a sequence of thin Cu disks for several key isotopes such as: ^{24}Na, ^{43}K, ^{52}Mn, and ^{59}Fe. Preliminary data (not yet reproduced) exist only for the production of ^{24}Na in a target of 20 Cu disks (each 0.1 cm thin) irradiated with 44 GeV ^{12}C. One observed a rather “flat” distribution of ^{24}Na yields within the first millimeters of Cu, followed by a strong yield increase further downstream. This experiment should be reproduced and studied for various reaction products.

MODELS OF MIXED QUARK-HADRON MATTER

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The problem of the mixed quark-hadron matter, that can arise at nuclear collisions, is addressed. It is shown that there can exist several different kinds of such a mixed matter. Before comparing theoretical results with experiments, one has to analyze thermodynamic stability of all these mixed states, classifying them onto unstable, metastable, and stable. Only the most stable mixed state should be compared with experiment. In addition to thermodynamic instability, there exists dynamic instability occurring in a mixture of components moving with respect to each other. This effect, called counterflow instability, has also to be taken into account, since it can lead to the stratification of mixed matter.

"TOMOGRAPHY"OF THE CLUSTER STRUCTURE OF LIGHT NUCLEI VIA RELATIVISTIC DISSOCIATION

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Thanks to its record spatial resolution and sensitivity, the method of nuclear track emulsions allowed carrying out a "tomography" for a whole family of light nuclei, including neutron deficient ones. In the case of peripheral interactions a relativistic scale of collisions of nuclei not only does not impede investigation of the cluster aspects of nuclear structure, but also offers advantages for studying few-particle ensembles. The facts collected in "mosaic" in these notes can serve as experimental "lighthouses" for developing theoretical concepts of nuclear clustering as well as for planning new experimental studies with relativistic nuclei.

In general, the presented results confirm the hypothesis that the known features of light nuclei define the pattern of their relativistic dissociation. The probability distributions of the final configuration of fragments allow their contributions to the structure of the investigated nuclei to be evaluated. These distributions have an individual character for each of the presented nuclei appearing as their original "autograph". The nuclei themselves are presented as various superpositions of light nuclei-cores, the lightest nuclei-clusters and nucleons. Therefore, the selection of any single or even a pair of configurations would be a simplification determined by the intention to understand the major aspects of nuclear reactions and nuclear properties rather than the real situation. The data presented are intended to help estimate the degree and effects of such simplifications.

A SUMMARY OF EXPERIMENTAL RESULTS ON THE REACTIONS IN URANIUM SAMPLES IRRADIATED WITH A DEUTERON BEAM OF ENERGIES UP TO 8 GeV AT THE QUINTA TARGET

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During the last runs of JINR NUCLOTRON the uranium samples of different abundance (natural uranium abundance, ^{235}U, ^{238}U) were placed at the QUINTA target (500 kg of natural uranium) in order to investigate the dependence of reaction rates of produced nuclei on a beam energy and on a position of samples within the target. The whole target was irradiated with deuteron beams of the total number of particles up to $5 \cdot 10^{13}$ and of the maximum energy of 8 GeV. Via spallation reaction, a varied neutron field has been originated. A response to produced neutrons represents a main task of this field of research. Activation measurement technique as well as gamma ray spectroscopy was utilized to obtain results of the reaction rates of (n,g), (n,2n), and (n,f) reactions.

As follows from results for uranium samples situated on the top of the QUINTA target, obtained during 6 GeV irradiation, a ratio of reaction rate for ^{239}Np production (non-threshold (n,g) reaction) vs. ^{237}U production ((n,2n) threshold reaction) is 2.9(3) times higher than the ratio for uranium sample in the middle of the target. It indicates how modified the neutron spectrum is depending on the target radius. In addition, for these sample positions the mean energy of neutron spectra was calculated with the use of MCNPX code. The value 24.3 MeV belongs to the inner sample position; the mean energy of neutrons in uranium sample on the top of the target was determined as 3.4 MeV, however.

Regarding the uranium samples in the central region of the QUINTA target, the total number of fission rises with increasing beam energy in the order of 10^{-4} per one gram of sample and one deuteron of beam. On the other hand, the total number of fission per one gram and deuteron and per one GeV of the beam seems to remain constant within the whole energy region. Furthermore, no relevant changes in mass distribution of fission products have been detected depending on increase in the beam energy.

Moreover, during the last run, some natural uranium samples were completely shielded in 1 mm cadmium layer in order to determine an influence of thermal neutrons. These samples were also placed in the central part of the QUINTA target. Whereas no significant contribution of thermal neutrons to fission of uranium samples could have been observed during 1 GeV and 8 GeV irradiations, the value of 1.33(6) represents the ratio of total/fast fission during the 4 GeV run. In most likelihood, it can be influenced by the significant shift of the beam from the center during the last mentioned run.

CURRENT STATUS OF THE MUON G-2 PROBLEM

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Review is given on the current status of experimental and theoretical status of the muon g-2 problem [1]. Prospects of new experiments on more precise measurements of the muon g-2 are briefly discussed. From theoretical side a special attention paid to the problem of calculations of hadronic contributions to the muon g-2. In particular, the light-by-light contribution from the lightest neutral pseudoscalar and scalar mesons to the anomalous magnetic moment of muon is considered in the framework of the nonlocal SU(3)xSU(3) quark model [2, 3]. The model is based on the four-quark interaction of the Nambu–Jona-Lasinio type and Kobayashi–Maskawa–t'Hooft six-quark interaction. Full kinematic dependence of vertices with off-shell mesons and photons in intermediate states in the light-by-light scattering amplitude is taken into account.

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SPATIAL DISTRIBUTION OF NATURAL U FISSION RATE IN QUINTA SUBCRITICAL ASSEMBLY IRRADIATED BY 1, 4, 6 AND 8 GEV DEUTERON'S BEAMS

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The experiments described in the paper were done within the framework of the research program "Investigations of physical aspect of electronuclear energy generation and atomic reactors radioactive waste transmutation using high energy beams of synchrophasotron/nuclotron JINR" in Laboratory of High Energy Physics (JINR, Dubna, Russian Federation).

The experimental subcritical setup "QUINTA" contains five sections. Each section is composed of uranium rods arranged in the form of hexagonal (triangular) lattice with pitch size of 3.6 cm. Whole setup contains total of 512.56 kg of natural uranium.

The experimental setup were irradiated by deuteron beams of energies 1, 4, 6 and 8 GeV. The beams were produced by superconducting, strong focusing synchrotron named Nuclotron (Laboratory of High Energy Physics).

The axis of the setup was aligned with beam axis with the help of the adjustable stand under the whole setup. The alignment of the beam center with the center of the setup was achieved by examining Polaroid films placed in front of the target and exposed to a couple deuteron pulses prior to the installation of the sample plates and the start of the main irradiation. Deuteron's beams shape and position on the target were obtained from track density distribution on the irradiated track detectors.

Information on the spatial distribution of fission reaction rate in the volume of the setup was obtained with sets of track detectors (SSNTD) coupled with ^{nat}U foils. Activation method was used to obtain the spatial distribution of $^{238}U(n,f)$ reaction. Sensors were placed on sample plates at different radial distances. 30 samples were used in each experiment.

The results obtaining during the experiments were used to calculate neutron-physical characteristic of the subcritical assembly i.e. the total number of fission, spectral indexes and neutron spectra of the setup during irradiation.

The simulations of the experiment were done with a FLUKA2011 Monte-Carlo code. Comparison experimental results and simulation is also presented.

RESULTS OF HBT MEASUREMENTS IN $^{12}C+^{12}C$ COLLISIONS AT MOMENTUM 4.2 A GeV/c

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Using the approach suggested by Hanbury-Brown and Twiss (HBT), we have studied the experimental data from $^{12}C+^{12}C$ collisions at 4.2A GeV/c. These data are obtained with the 2-m propane bubble chamber of LHE, JINR. The high accuracy of the data provides a reliable basis for the analysis of the momentum distribution of the secondary particles produced in this reaction. The HBT analysis indicates on the presence of quantum correlations for the secondary particles at low relative momenta $\sim$ 200MeV/c. In contrast, the two-particle momentum correlation functions obtained with the same data do not manifest any correlations in this region. The obtained results are compared with the predictions of the Ultrarelativistic Quantum Molecular Dynamics model (UrQMD). It appears that the UrQMD predictions disagree with the results of the HBT analysis which may indicate on the limitation of the UrQMD at this region.

PSEUDORAPIDITY SPECTRA OF SECONDARY PARTICLES EMITTED IN THE RELATIVISTIC NUCLEUS-NUCLEUS COLLISIONS

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We discuss new results connected with structure of the pseudorapidity spectra of charged relativistic particles with $\beta > 0.7$ produced in Si, Au and Pb+Em reactions. The relativistic nucleus beams were obtained from AGS and SPS machines at energies: 4.0; 11.6; 14.0 and 158 A GeV. The pseudorapidity spectra were analyzed using Fourier transformation and maximum entropy methods. The number of fast target protons: g-particles are used to fix the centrality of collisions. Both applied methods detected the existing of some selected pseudorapidity values – nontrivial structure. The results coming from the maximum entropy method are cleaner and comfortable to use. Meanwhile the method cannot give the information on the errors for the selected pseudorapidity values and the width of the maximums corresponding to the selected values. Nevertheless we can say that A number of the selected pseudorapidity values depend on energy; it increased from 2 to 4 with energy and decreased with a number of g-particles.

HADES EXPERIMENTS INVESTIGATING IN-MEDIUM HADRON PROPERTIES

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The HADES spectrometer installed at GSI Darmstadt is a second generation experiment designed to measure e^+e^- pairs (dielectrons) in the SIS/BEVALAC energy regime. The main goal of the experiment is to measure electromagnetic emissivity of a compressed baryonic matter formed in course of heavy ion collisions and ultimately learn about in-medium hadron properties. For this purpose a dedicated programme focusing on systematic investigation of dielectron production in nucleon-nucleon, proton-nucleus and heavy ion reactions is on-going. A comparison of the nucleon-nucleon data to the one obtained in more complex systems allows for isolation of true in-medium effects. Furthermore, thank to excellent particle identification capabilities of the detector, investigations have also been extended to strangeness production, which at these energies is confined to a high density zone of the collision. In particular intriguing new results on hadrons containing two strange quarks (ϕ and $\Xi(1321)$) were obtained. In the talk overview of results obtained so far will be given and also perspective for future investigations, in particular in new FAIR project, will be addressed.

R&D FOR THE PANDA BARREL DIRC

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The PANDA experiment at the new Facility for Antiproton and Ion Research in Europe (FAIR) at GSI, Darmstadt, will study fundamental questions of hadron physics and QCD using high-intensity cooled antiproton beams with momenta between 1.5 and 15 GeV/c. Efficient Particle Identification (PID) for a wide momentum range and the full solid angle is required for reconstructing the various physics channels of the PANDA program. Hadronic PID in the barrel region of the detector will be provided by a DIRC (Detector of Internally Reflected Cherenkov light) counter. The design is based on the successful BABAR DIRC with important improvements, such as focusing optics and fast photon timing. The PANDA DIRC detector, including a number of design options, was modeled in a detailed Geant simulation and studied with a fast reconstruction algorithm. Designs were evaluated based on the single photon Cherenkov angle resolution and the photon yield. Several design choices, including different radiator geometries and optics, were tested in particle beams at GSI and CERN. In this contribution the design options, performance of the detector prototype, simulation and reconstruction will be discussed.