MESON2016

13th International Workshop
on Meson Production, Properties and Interaction

Thursday 02 June 2016 - Tuesday 07 June 2016

Auditorium Maximum
of the Jagiellonian University
Kraków, Poland

Book of Abstracts

Contents

Plenary Session /

Recent results on tetra- and penta-quark candidates at LHCb

SKWARNICKI, Tomasz[1]

[1]Syracuse University

for the LHCb Collaboration

Corresponding Author(s): tskwarni@syr.edu

Thanks to its unique capabilities the LHCb experiment has been making important measurements related to exotic hadron candidates. Two $J/\psi p$ resonances consistent with pentaquark states were observed last year in Λ_b decays to $J/\psi p K^-$. This measurement will be discussed together with more recent follow up work. New results on tetraquark candidates will also be presented.

Plenary Session /

Exotics at BESIII

WANG, Zhiyong[1]

[1]IHEP,CAS

for the BESIII Collaboration

Corresponding Author(s): wangzy@ihep.ac.cn

With the data taking at BESIII detector, we perform a search of exotics, including X, Y, and Z states. As a result, we observed X(1835) in $J/psi \to \gamma p\bar{p}$, observed X(3823) in $e^+e^- \to \pi^+\pi^-\chi_{c1}$. We confirmed X(3872) in $e^+e^- \to \gamma\pi^+\pi^- J/\psi$. We observed a possible resonance Y(4220) in the line-shape of $e^+e^- \to \pi^+\pi^- J/\psi$, which is quite different from the Y(4260) reported by BaBar and Belle experiments. We observed charged and neutral $Z_c(3900)$ and $Z_c(4020)$ in $e^+e^- \to \pi\pi J/\psi, \pi\pi h_c$, respectively, and observed charged and neutral $Z_c(3885)$ and $Z_c(4025)$ in $e^+e^- \to \pi(DD^*), \pi(D^*D^*)$, respectively.

Plenary Session /

Exotic mesonic and baryonic objects in lattice QCD

RYAN, Sinead[1]

[1]Trinity College Dublin

Corresponding Author(s): ryan@maths.tcd.ie

Recent progress in lattice calculations of exotic hadronic states is reviewed. The theoretical and algorithmic advances that are enabling new calculations are described and results from heavy and light quark systems are presented. The challenges for lattice exotic hadron spectroscopy are highlighted.

Plenary Session /

Pentaquarks, doubly heavy exotic mesons and baryons and how to look for them

KARLINER, Marek[1]

[1]Tel Aviv University

Corresponding Author(s): marek@proton.tau.ac.il

I discuss the experimental evidence for and theoretical interpretation of the new mesons and baryons with two heavy quarks. These include doubly-heavy baryons, exotic hadronic quarkonia and most recently a manifestly exotic pentaquark-like doubly heavy baryon with a minimal quark content $uud\bar{c}$ discovered by LHCb, whose mass, decay mode and width are in agreement with a prediction based on a physical picture of a deuteron-like "hadronic molecule".

Plenary Session /

Overview of the status/results in the exotics sector

SHEN, Chengping[1]

[1]Beihang University

Corresponding Author(s): shencp@buaa.edu.cn

Exotic hadronic states with other configurations have been searched for and many candidates were proposed including glueballs, hybrids, multi-quark states, and hadron molecules. Since a proton and a neutron can be bounded to form a deuteron, it is also believed that other states beyond the quark model must exist. Dramatic progress was made in the study of the exotic states after the discovery of the $X(3872)$. In my this review report, I present the most recent results on the study of the XYZ states from the BESIII, Belle, LHCb, D0 experiments, and so on. Meanwhile, I also show some possible theoretical explanations for them.

Plenary Session /

Review of dark photon searches

DENIG, Achim[1]

[1]JGU Mainz

Corresponding Author(s): denig@kph.uni-mainz.de

Dark Photons are hypothetical extra-U(1) gauge bosons, which are motivated by a number of astrophysical anomalies as well as the presently seen deviation btw. the Standard Model prediction and the direct measurement of the anomalous magnetic moment of the muon. We review recent searches for such a Dark Photon, which are carried out at various hadron physics facilities.

Parallel Session A1

Determination of the ω- and η'-Nb optical potential

NANOVA, Mariana[1] ; METAG, Volker[2]

[1]University of Giessen, Germany

[2]II.Physikalisches Institut, Universität Giessen

for the CBELSA/TAPS Collaboration

Corresponding Author(s): mariana.nanova@exp2.physik.uni-giessen.de

The interaction of ω and η' mesons with nuclei has been studied in photo production off C and Nb targets, using the CBELSA/TAPS detector system. Transparency ratio measurements provide information on the inelastic cross section and in-medium width of mesons and thereby on the imaginary part of the meson-nucleus potential [1]. The real part of the optical potential can be deduced from measurements of the excitation function and momentum distribution which are sensitive to the sign and depth of the potential. Data taken on a C and Nb target have been analysed to determine the real and the imaginary part of the ω- and η'-nucleus optical potential. The momentum dependence of the imaginary part of the optical potential will be presented and discussed for both mesons. The results are compared to previous experimental results [2,3] and to model calculations assuming different scenarios for the in-medium properties of the ω and η' meson. The data are consistent with a weakly attractive potential for both mesons. The relatively small in-medium width of the η' meson encourages the search for η' bound states.

[1] M. Nanova et al., Phys. Lett. B 710 (2012) 600
[2] M. Nanova et al., Phys. Lett. B 727 (2013) 417
[3] M. Kotulla et al., Phys. Rev. Lett. 100 (2008) 192302

⋆Funded by DFG(SFB/TR-16)

Parallel Session A1 /

Trapping of Σ^+ hyperons in nuclei

WYCECH, Sławomir[1]

[1]National Centre of Nuclear Studies , Poland

Corresponding Author(s): wycech@fuw.edu.pl

The nuclear capture of K^- studied by FINUDA [1] in reaction $K^-\,{}^6\mathrm{Li} \to \Sigma^+\pi^- A'$ discovered a puzzling low momentum component in the spectrum of final Σ^+ hyperon. This component does not exist in the Σ^- emission. We interpret it as the effect of Gamov state formed by the hyperon. Such state is quasi-localized in space with a radius in between the hyper-nuclear and the hyper-atomic radius. The experimental and theoretical consequences of this discovery are studied. First, to create Gamov state the nuclear potential has to attractive and close to the binding. Such conditions are likely in He. In light nuclei, the Gamov state happens at energies of few hundred KeV but widths of such states states are in MeV region. The shape of hyperon momentum distribution yields information on the related width and hence on the strength od hyperon absorption in nuclei. There are other experimental indications of related low energy "anomaly" known from old emulsion studies [2]. If this phenomenon is supported with measurements in heavier nuclei it may open a new section in the hypernuclear studies.

[1] M. Angelo for FINUDA arXiv 1109.6594v1, Phys. Lett. B704 (2011) 474-480

[2] D. F. Kane Dublin University Thesis

Parallel Session A1 /

ηN interactions in the nuclear medium and η-nuclear bound states

Author(s): MARES, Jiri[1]
Co-author(s): BARNEA, Nir[2] ; CIEPLY, Ales[3] ; FRIEDMAN, Eliahu[4] ; GAL, Avraham[5]

[1]Nuclear Physics Institute, Rez

[2]Hebrew University, Jerusalem

[3]Nuclear Physics Institute

[4]Racah Institute of physics, Hebrew University, Jerusalem

[5]Hebrew University, Jerusalem, ISRAEL

Corresponding Author(s): mares@ujf.cas.cz

Recent calculations of η-nuclear bound states in few-body, as well as many-body systems are reviewed [1,2,3]. Underlying energy-dependent ηN interactions are derived from coupled-channel models that incorporate the S_{11} $N^*(1535)$ nucleon resonance.
The role of self-consistent handling of the subthreshold, strongly energy-dependent ηN interactions is thoroughly discussed. Due to relatively large downward energy shift and rapid decrease of the ηN amplitudes, our calculations impose stronger constraints than ever on the onset of η-nuclear binding.
Binding energies and widths of η-nuclear bound states were calculated within several ηN interaction models for nuclei across the periodic table. No ηNN bound states were found in models where Re$a_{\eta N} \leq 1$ fm, with $a_{\eta N}$ the ηN scattering length, i.e., in the majority of coupled-channel models of the $N^*(1535)$ resonance. For ηNNN, a weakly bound and relatively broad state was found within the GW model [4] where Re$a_{\eta N} \approx 1$ fm. Bound states of the η meson in ^{12}C are unlikely in models with Re$a_{\eta N} \leq 0.5$ fm, and Re$a_{\eta N} \approx 0.9$ fm is required to reproduce the η bound-state candidate in ^{25}Mg from the COSY-GEM experiment [5].
[1] N. Barnea, E. Friedman, A. Gal, Phys. Lett. B 747 (2015) 345
[2] E. Friedman, A. Gal, J. Mares, Phys. Lett. B 725 (2013) 334
[3] A. Cieply, E. Friedman, A. Gal, J. Mares, Nucl. Phys. A 925 (2014) 126
[4] A. M. Green, S. Wycech, Phys. Rev. C 71 (2005) 014001
[5] A. Budzanowski et al (COSY-GEM Collaboration), Phys. Rev. C 79 (2009) 012201(R)

Parallel Session A1 /

Search for η' mesic nuclei by missing-mass spectroscopy of ^{12}C(p,d) reaction

TANAKA, Yoshiki K.[1]

[1]University of Tokyo

for the η-PRiME Collaboration

Corresponding Author(s): tanaka@nucl.phys.s.u-tokyo.ac.jp

We measured excitation spectra in the ^{12}C(p,d) reaction around the η' emission threshold to search for eta' meson bound states in carbon nuclei (η' mesic nuclei). A 2.5 GeV proton beam from the SIS synchrotron impinged on a carbon target to potentially produce eta'

mesic nuclei via the $^{12}\mathrm{C}(p, d)$ reaction. The ejected deuterons were momentum-analyzed by FRS used as a high-resolution spectrometer. An extremely good statistical sensitivity was achieved in the measured excitation spectra as well as a sufficiently good energy resolution. In this contribution, the analysis on the excitation spectra and the preliminary results are presented.

Parallel Session B1 /

Exclusive diffractive production of $\pi^+\pi^-$ continuum and resonances within tensor pomeron approach

Author(s): LEBIEDOWICZ, Piotr[1]
Co-author(s): SZCZUREK, Antoni[2] ; NACHTMANN, Otto[3]

[1]Institute of Nuclear Physics PAN

[2]Institute of Nuclear Physics PAN, Krakow and Rzeszow University, Rzeszow

[3]Institut f\"ur Theoretische Physik, Universit\"at Heidelberg

Corresponding Author(s): piotr.lebiedowicz@ifj.edu.pl

We discuss exclusive central diffractive dipion production in the reactions $pp \to pp\pi^+\pi^-$ and $p\bar{p} \to p\bar{p}\pi^+\pi^-$ at high energies. The calculation is based on a tensor pomeron model and the amplitudes for the processes are formulated in an effective field-theoretic approach [1]. We include the purely diffractive dipion continuum, and the scalar and tensor resonances decaying into the $\pi^+\pi^-$ pairs [2, 3] as well as the photoproduction contributions (ρ^0, Drell-S\"oding) [4]. We discuss how two pomerons couple to tensor meson $f_2(1270)$ and the interference effects of resonance and dipion continuum for the first time. The theoretical results are compared with existing STAR, CDF, and CMS experimental data. Predictions for planned or being carried out experiments (ALICE, ATLAS) are presented. We show the influence of the experimental cuts on the integrated cross section and on various differential distributions for outgoing particles. Distributions in rapidities and transverse momenta of outgoing protons and pions as well as correlations in azimuthal angle between them are presented. We find that the relative contribution of resonant $f_2(1270)$ and dipion continuum strongly depends on the cut on proton transverse momenta (or four-momentum transfer squared $t_{1,2}$) which may explain some controversial observations made by different ISR experiments in the past. The cuts may play then the role of a $\pi\pi$ resonance filter. We suggest some experimental analyses to fix model parameters related to the pomeron-pomeron-meson coupling.
[1] C. Ewerz, M. Maniatis, and O. Nachtmann, Annals Phys. 342 (2014) 31
[2] P. Lebiedowicz, O. Nachtmann, and A. Szczurek, Annals Phys. 344 (2014) 301
[3] P. Lebiedowicz, O. Nachtmann, and A. Szczurek, Phys. Rev. D93 (2016) 054015
[4] P. Lebiedowicz, O. Nachtmann, and A. Szczurek, Phys. Rev. D91 (2015) 074023

Parallel Session B1 /

Role of Deck-like backgrounds in diffractive production of $\pi^-\pi^-\pi^+$ and $\pi^-\pi^0\pi^0$ systems at COMPASS

RYABCHIKOV, Dmitry[1]

[1]TU Muenchen and IHEP Protvino

for the COMPASS Collaboration

Corresponding Author(s): ryabchik@cern.ch

The COMPASS experiment is a multi-purpose fixed-target spectrometer located at CERN Super Proton Synchrotron aimed at studying the structure and spectrum of hadrons. The numerous results in spectroscopy of light mesons were obtained by investigations of various diffractive-dissociation reactions with 190 GeV/c π^- beam impinging on liquid-hydrogen target. The flagship reaction is $\pi^- p \to \pi^-\pi^-\pi^+ p$ with the worlds largest statistics of more than $5 \cdot 10^7$ events. The charge-partner reaction is $\pi^- p \to \pi^-\pi^0\pi^0 p$

with statistics of about $4 \cdot 10^6$ events. The data clearly demonstrates signals of mesonic resonances and also features the presence of non-resonant coherent background called Deck mechanism. We will present studies of a model of the Deck process and compare it to the COMPASS data for both $\pi^-\pi^-\pi^+$ and $\pi^-\pi^0\pi^0$ final states.

Parallel Session B1 /

Amplitude analysis of resonant production in three pions

Author(s): JACKURA, Andrew[1] ; MIKHASENKO, Mikhail[2]
Co-author(s): SZCZEPANIAK, Adam[3]

[1]Indiana University

[2]Institute for High Energy Physics, Protvino

[3]Indiana University/ JLab

for the Joint Physics Analysis Center Collaboration

Corresponding Author(s): ajackura@indiana.edu

We present some results on the analysis of three pion resonances. The analyses are motivated by the recent release of the largest data set on diffractively produced three pions by the COMPASS collaboration. We construct reaction amplitudes that satisfy fundamental S-matrix principles, which allows the use of models that have physical constraints to be used in fitting data. The models are motivated by the isobar model that satisfy unitarity constraints. The model consist of a Deck production amplitude with which final state interactions are constrained by unitarity. We employ the isobar model where two of the pions form a quasi-stable particle. The analysis is performed in the high-energy, single Regge limit. We specifically discuss the examples of the three pion $J^{PC} = 2^{-+}$ resonance in the $\rho\pi$ and $f_2\pi$ channels.

Parallel Session B1 /

Pion and eta production in elementary and heavy-ion collisions at SIS energies

GUMBERIDZE, Małgorzata[1]

[1]TU Darmstadt

for the HADES Collaboration

Corresponding Author(s): m.gumberidze@gsi.de

Pion production is the dominating inelastic process in nucleus-nucleus collisions. At beam energies on the order of 1 - 2 GeV per nucleon pions are predominantly created via the excitation and the decay of hadron resonances. The $\Delta(1232)$ baryon resonance is most copiously produced, but as the incident energy increases, higher lying resonances, such as $N(1440)$, $N(1520)$, $N(1535)$, $\Delta(1600)$, etc., also contribute to pion production in a wide energy range and to η production close to threshold. These contributions stand out clearly in the dielectron invariant mass distributions measured in elementary and heavy-ion collisions at SIS18 energies. A detailed description of the resonance and meson production in elementary hadronic collisions is indeed a crucial ingredient of transport model calculations. In this contribution we present the results of a study of pion and eta

production in pp, pA and AA collisions measured with HADES at GSI. The main focus will be on 40% most central Au(1.23 GeV)+Au collisions. Our results contribute with an unprecedented statistics to systematic studies of pion production in heavy ion collisions. The yields, transverse mass and angular distributions are compared with transport model calculations as well as with existing data from other experiments.
This work has been supported by TU Darmstadt: VH-NG-823, Helmholtz Alliance HA216/EMMI and GSI.

Parallel Session A2 /

Search for new physics in rare and semi-rare decays of B-mesons at ATLAS

PRICE, Darren[1]

[1]University of Manchester

for the ATLAS Collaboration

Corresponding Author(s): darren.price@cern.ch

Processes involving the FCNC transitions in b-hadron decays are suppressed in the SM and are sensitive to new physics. New results in the search for the rare decays of B_s and B_d into μ^+mu^- are presented. They are based on the full sample of data collected by ATLAS at 7 and 8 TeV collision energy. The consistency with the SM and with other available measurements is discussed. The properties of the decay of the B_d meson into $K^*\mu^+\mu^-$ are also sensitive to the presence of New Physics in loops and has received renewed interest because of possible deviations from the standard model in this decay observed by LHCb. We present recent results obtained by ATLAS, concerning the angular distribution parameters FL, S_i and P_i' in the region $Q^2(\mu^+\mu^-) < 6\ GeV^2$.

Parallel Session A2 /

The $B_c \to J/\psi KD$ weak decay and its relation with the $D_{s0}^*(2317)$ resonance

Author(s): FERNANDEZ-SOLER, Pedro[1]
Co-author(s): OSET, Eulogio[2] ; SUN, Zhi-Feng[3] ; BAYAR, Melahat[4]

[1]Instituto de Física Corpuscular (IFIC). University of Valencia.

[2]University of Valencia

[3]Instituto de Física Corpuscular (IFIC) - University of Valencia

[4]Kocaeli University

Corresponding Author(s): p.fdez.s.90@gmail.com

We study the presence of the $D_{s0}^*(2317)$ resonance in the weak decay process: $B_c \to J/\psi KD$. We assume a weak interaction mechanism in which the b quark decays into a $c\bar{c}$ (J/ψ) and $\bar{s}$ via a W meson. In this process the $c\bar{s}$ pair hadronizes and the possible final configurations considered are KD and ηD_s. We compute the interaction of these two meson channels in the chiral unitary approach. Then we consider the $D_{s0}^*(2317)$ as mainly a KD molecular state, and we fit the parameters of the theory in order to get a bound state pole in the S-matrix at the experimental mass of the $D_{s0}^*(2317)$. We also consider the possibility of an additional q anti-q component in the $D_{s0}^*(2317)$, introducing a CDD pole in the potential that describes the interaction. In these possible scenarios we predict the ratio of the invariant mass distribution $(B_c \to J/\psi KD)/(B_c \to D_{s0}^*(2317))$. In all cases the invariant mass distribution peaks very close to the KD threshold suggesting the presence of the $D_{s0}^*(2317)$ resonance.
Based on "$D_{s0}^*(2317)^+$ in the decay of B_c into $J/\psi DK$". Phys. Rev. D, in print. arXiv:1510.06316 [hep-ph].

Parallel Session A2 /

Molecular components in $D^*_{s0}(2317)$ and $D_{s1}(2460)$ mesons

Author(s): ORTEGA, Pablo G.[1]
Co-author(s): SEGOVIA, Jorge[2] ; ENTEM, David R.[3] ; FERNANDEZ, Francisco[3]

[1]CERN (European Organization for Nuclear Research)

[2]Technische Universität München

[3]Universidad de Salamanca

Corresponding Author(s): jorge.segovia@tum.de

Results obtained by various experiments show that the $D^*_{s0}(2317)$ and $D_{s1}(2460)$ mesons are very narrow states located, respectively, below the DK and D^*K thresholds. This has led much attention because it is markedly in contrast with the expectations from naive quark models and heavy quark symmetry [1]. Early lattice QCD studies found D^*_{s0} and D_{s1} energy levels in line with quark model expectations (see, for instance, Ref. [2]). Motivated by a recent lattice study [3, 4] which addresses the mass shifts of the $c\bar{s}$ ground states with quantum numbers $J^P = 0^+$ ($D^*_{s0}(2317)$) and $J^P = 1^+$ ($D_{s1}(2460)$) due to their coupling with S-wave DK and D^*K thresholds, we perform a similar analysis within a nonrelativistic constituent quark model in which quark-antiquark and meson-meson degrees of freedom are incorporated. The quark model has been applied to a wide range of hadronic observables and thus the model parameters are completely constrained (see references [5, 6] for reviews). The coupling between quark-antiquark and meson-meson Fock components is done using a $^3P_0$ model in which its only free parameter γ has been elucidated performing a global fit to the decay widths of mesons that belong to different quark sectors [7].
We observe that the S-wave coupling of the 0^+ (1^+) meson sector to the DK (D^*K) threshold is a key feature in lowering the masses of the corresponding $D^*_{s0}(2317)$ and $D_{s1}(2460)$ states predicted by the naive quark model, but also in describing the $D_{s1}(2536)$ meson as the 1^+ state of the $j^P_q = 3/2^+$ doublet predicted by heavy quark symmetry and thus reproducing its strong decay properties. Two features of our formalism cannot be address nowadays by lattice computations: the coupling of the D-wave D^*K threshold in the $J^P = 1^+$ channel and the computation of the probabilities associated with different Fock components in the physical state.
[1] S.N. Gupta and J.M. Johnson, Phys. Rev. D51, 168 (1995)
[2] G.S. Bali Phys. Rev. D68, 071501 (2003)
[3] D. Mohler et al., Phys. Rev. Lett. 111, 222001 (2013)
[4] C.B. Lang et al., Phys. Rev. D90, 034510 (2014)
[5] A. Valcarce et al., Rept. Prog. Phys. 68, 965 (2005)
[6] J. Segovia et al., Int. J. Mod. Phys. E22 1330026 (2013)
[7] J. Segovia, D.R. Entem and F. Fernandez, Phys. Lett. B715, 322 (2012)

Parallel Session A2 /

Diffractive production of heavy mesons at the LHC

Author(s): LUSZCZAK, Marta[1]
Co-author(s): SZCZUREK, Antoni[2]

[1]University of Rzeszow

[2]Institute of Nuclear Physics PAN, Krakow and Rzeszow University, Rzeszow

Corresponding Author(s): luszczak@univ.rzeszow.pl

We discuss diffractive production of open charm and bottom mesons at the LHC [1]. The differential cross sections for single- and central-diffractive mechanisms for $c\bar{c}$ and $b\bar{b}$ pair production are calculated in the framework of the Ingelman-Schlein model corrected for absorption effects. In this approach one assumes that the pomeron has a well defined partonic structure, and that the hard process takes place in a pomeron-proton or proton-pomeron (single diffraction) or pomeron-pomeron (central diffraction) processes. Here, leading-order gluon-gluon fusion and quark-antiquark anihilation partonic subprocesses are taken into consideration. Both pomeron flux factors as well as parton distributions in the pomeron are taken from the H1 Collaboration analysis of diffractive structure function and diffractive dijets at HERA. The extra corrections from subleading reggeon exchanges are explicitly calculated and are also taken into consideration. Predictions for single- and central-diffractive production in the case of inclusive D and B mesons, as well as $D\bar{D}$ correlations are presented, including detector acceptance of the ATLAS, CMS and LHCb Collaborations. The experimental aspects of possible standard and dedicated measurements are carefully discussed.
For the first time, the differential cross sections for the diffractive $c\bar{c}$ pair production are calculated in the framework of the k_t-factorization approach, i.e. effectively including higher-order corrections. The unintegrated (transverse momentum dependent) diffractive parton distributions in proton are calculated with the help of the Kimber-Martin-Ryskin prescription where collinear diffractive PDFs are used as input. The latter are obtained by means of the Ingelman-Schlein model. Several quark-level differential cross sections are shown, including one-dimensional distribution and two-dimensional correlation distributions (e.g. $\varphi_{c\bar{c}}$-azimuthal angle correlations or pair transverse momentum p_t distributions. The hadronization of charm quarks is taken into account by means of fragmentation function technique. Predictions for single-diffractive production of D^0 meson including detector acceptance of the ATLAS experiment are presented. Crucial aspects of possible standard and dedicated measurements within the ATLAS detector are also discussed.
[1] M. Luszczak, R. Maciula and A. Szczurek, Phys. Rev. D 91 (2015), 054024
[2] M. Luszczak, R. Maciula, A. Szczurek and M. Trzebinski, Diffractive charm production at the LHC within k_t -factorization approach, a paper in preparation

Parallel Session A2 /

Search for dark forces with KLOE

Author(s): GRAZIANI, Enrico[1]
Co-author(s): CURCIARELLO, Francesca[2]

[1]INFN Roma3

[2]INFN

for the KLOE2 Collaboration

Corresponding Author(s): fcurciarello@unime.it, alek.gajos@gmail.com

During the last years several Dark Sector Models have been proposed in order to address striking astrophysical observations which failed standard intepretations. In the minimal case a new vector particle, the so called dark photon or U boson, is introduced, with small coupling with Standard Model particles. Also, the existence of a dark Higgs boson h' is postulated, in analogy with the Standard Model, to give mass to the U boson through the Spontaneous Symmetry Breaking mechanism.
The experiment KLOE, working on the DAFNE e^+e^- collider in Frascati, searched for the existence of the U boson in a quite complete way, investigating three different processes and six different final states:

- in dalitz decays of the ϕ meson $\phi \to \eta U$, with $U \to e^+e^-$ and $\eta \to \pi^+\pi^-\pi^0$ and $\pi^0\pi^0\pi^0$
- in $e^+e^- \to U\gamma$ events, with U decaying to electron, muon and pion pairs
- in the dark Higgsstrahlung process, $e^+e^- \to Uh'$, $U \to \mu^+\mu^-$, h' invisible.

Tight limits on the model parameters have been set at 90% CL. Further improvements are expected in terms of sensitivity and discovery potential with the new KLOE2 detector working on the improved DAFNE e^+e^- collider.

Parallel Session B2 /

Constraints of hadronic interactions in extensive air showers with the Pierre Auger Observatory

ESPADANAL, João[1]

[1]LIP - Laboratório de Instrumentação e Física Experimental de Partículas

for the Pierre Auger Collaboration

Corresponding Author(s): jespada@lip.pt

The Pierre Auger Observatory allows the study of ultra-high energy cosmic rays around and above 100 eV center-of-mass energy, inaccessible to accelerator experiments. A single cosmic ray initiate a chain reaction of billions interactions called extensive air showers. These interactions rely on extrapolations and in kinematic regions beyond those tested at accelerators.
We report the constrains on the post LHC-tuned hadronic model by the number of muons at the ground, the muon production depth and also the measurement of the proton-air cross section for particle production at a center-of-mass energy per nucleon of 39 and 57 TeV at Auger. The measurements are based on the longitudinal, lateral, and temporal distribution of particles in air showers recorded by the observatory and are sensitive to primary mass composition and to properties of the hadronic interactions in the shower.

Parallel Session B2 /

Constraints on atmospheric charmed-meson production from IceCube

PALCZEWSKI, Tomasz[1]

[1]University of California and LBNL

for the IceCube Collaboration

Corresponding Author(s): tpalczewski@lbl.gov

IceCube's detection of ultra-high energy neutrino events heralds the beginning of neutrino astronomy. At very-high energies (100 TeV - 1 PeV), the dominant background to the astrophysical signal is the flux of prompt neutrinos, coming from the semi-leptonic decay of charmed mesons produced by cosmic ray collisions in the atmosphere. This is due to the very short lifetime of the charmed mesons, which therefore almost always decay before interacting. The small value of Bjorken-x at which the parton distribution functions are evaluated makes the calculation of this process very difficult. The charm quark has mass significantly above the ΛQCD scale, and therefore its production should be perturbatively calculable. However, the uncertainty in the data and the calculations can't exclude some smaller non-perturbative inset. In this talk, the constraints on charm contribution from IceCube studies of atmospheric muons and ultra-high energy neutrinos will be discussed. To evaluate the prompt neutrino flux, one needs the knowledge of the charm production cross section in $pN \to c\bar{c}X$, and hadronization of charm particles. The recent LHC data on charm production will be reviewed and approaches of the calculation of the prompt lepton flux will be discussed.

Parallel Session B2 /

Exclusive ρ^0 meson photoproduction with a leading neutron at HERA

SCHMITT, Stefan[1] ; GOERLICH, Lidia[2]

[1]DESY

[2]Institute of Nuclear Physics PAS

for the H1 Collaboration

Corresponding Author(s): lidia.goerlich@ifj.edu.pl

A first measurement is presented of exclusive photoproduction of ρ^0 mesons associated with leading neutrons at HERA. The data were taken with the H1 detector in the years 2006 and 2007 at a centre-of-mass energy of $\sqrt(s) = 319$ GeV and correspond to an integrated luminosity of 1.16 pb^{-1} . The ρ^0 mesons with transverse momenta $p_T < 1$ GeV are reconstructed from their decays to charged pions, while leading neutrons carrying a large fraction of the incoming proton momentum, $x_L > 0.35$, are detected in the Forward Neutron Calorimeter. The phase space of the measurement is defined by the photon virtuality $Q^2 < 2$ GeV^2, the total energy of the photon-proton system $20 < W_\gamma$, $p < 100$ GeV and the polar angle of the leading neutron $\theta_n < 0.75$ mrad. The cross section of the reaction $\gamma p \to \rho^0 n\pi^+$ is measured as a function of several variables. The data are interpreted in terms of a double peripheral process, involving pion exchange at the proton vertex followed by elastic photoproduction of a rho0 meson on the virtual pion. In the framework of one-pion-exchange dominance the elastic cross section of photon-pion scattering, $\sigma_{el}(\gamma\pi^+ \to \rho^0 p^+)$, is extracted. The value of this cross section indicates significant absorptive corrections for the exclusive reaction $\gamma p \to \rho^0 n\pi^+$.

Parallel Session B2 /

$\eta' - \pi$ production and search for exotic mesons at COMPASS and JLab12

Author(s): PAUK, Vladiszlav[1]
Co-author(s): MATHIEU, Vincent[2] ; SZCZEPANIAK, Adam[3]

[1]JLab

[2]Indiana University

[3]Indiana University/ JLab

Corresponding Author(s): paukvp@gmail.com

In a recent analysis of the exclusive production of $\eta - \pi$ and $\eta' - \pi$ meson systems with a 191 GeV/c pion beam on a proton target at COMPASS, an unexpected enhancement of $\eta' - \pi$ over $\eta - \pi$ was observed for the odd partial waves. These carry exotic quantum numbers therefore cannot be associated with the conventional quark-antiquark states. The collected data covers a wide range of the dimeson invariant masses extending to the region where the multi-particle production process enters the diffractive regime and can be well described by means of the theory of complex angular momentum, namely in terms of the t-channel exchanges of Regge trajectories. Assuming the analyticity and the multi-Regge behavior of the scattering amplitude at high energies, the finite energy sum rules for multiple production can be formulated. The sum rules give a consistency condition between a quasi-two-body Regge amplitude and a double Regge amplitude in the case of reactions with three particles in the final state. Such conditions allow to examine the analytical structure of the multi-particle production amplitudes and to shed light on the observed $\eta - \pi$ puzzle.

Parallel Session B2 /

Central exclusive production in proton-proton collisions with the STAR experiment at RHIC

GURYN, Wlodek[1]

[1]Brookhavem National Laboratory

for the STAR Collaboration

Corresponding Author(s): guryn@bnl.gov

We shall describe the physics program with tagged forward protons, focusing on Central Exclusive Production (CEP) in polarized proton-proton collisions at the Relativistic Heavy Ion Collider (RHIC), with the STAR detector at $\sqrt{s} = 200$ GeV. Preliminary results in CEP of two oppositely charged pions and kons produced in the processes $pp \to pp\pi^+\pi^-$ and $pp \to ppK^+K^-$ shall be presented. Those Double Pomeron Exchange (DPE) processes, allow the final states to be dominated by gluonic exchanges. Silicon strip detectors placed in Roman Pots were used for measuring forward protons. The preliminary results are based on the measurement of the recoil system of charged particles in the STAR experiment's Time Projection Chamber (TPC). Ionization energy loss, dE/dx, of charged particles was used for particle identification (PID). In addition to those preliminary results, the present status and future plans of the diffractive physics at RHIC shall be described.

Plenary Session /

Hadron reactions and spectroscopy studies and the Joint Physics Analysis Center

SZCZEPANIAK, Adam[1]

[1]Indiana University/ JLab

Corresponding Author(s): aszczepa@indiana.edu

I will review current activities and future plans for the Joint Physics Analysis Center.

Plenary Session /

Generalized Parton Distributions and the three-dimensional structure of mesons

MOUTARDE, Hervé[1]

[1]Irfu

Corresponding Author(s): herve.moutarde@cea.fr

The concept of Generalized Parton Distributions promises an understanding of the generation of the charge, spin, and energy-momentum structure of hadrons by their fundamental constituents, quarks and gluons. Forthcoming measurements with unprecedented accuracy will presumably challenge our quantitative description of the three-dimensional structure of hadrons. To fully exploit these future experimental data, new tools and models are currently being developed. We will explain the difficulties of Generalized Parton Distribution modeling, and present some recent progresses in the description of pions. In particular we will discuss various equivalent parameterizations and sketch how to combine them to obtain models satisfying a priori all required theoretical constraints. We will explain why these developments naturally fit in a versatile software platform, named PARTONS, dedicated to the phenomenology of GPDs.

Plenary Session /

Exclusive hard processes with mesons

PASSEK-KUMERIČKI, Kornelija[1]

[1]Rudjer Boskovic Institute

Corresponding Author(s): passek@irb.hr

The description of the exclusive hard processes with mesons within the perturbative QCD framework will be renewed. The application of such approach will be demonstrated on both pseudoscalar and scalar meson transition form factors, as well as, on deeply virtual production of mesons. The relevant recent Belle experimental results will be commented.

Plenary Session /

Pion-nucleon scattering: from chiral perturbation theory to Roy-Steiner equations

KUBIS, Bastian[1]

[1]Bonn University

Corresponding Author(s): kubis@hiskp.uni-bonn.de

Ever since Weinberg's seminal predictions of the pion-nucleon scattering amplitudes at threshold, this process has been of central interest for the study of chiral dynamics involving nucleons. The scattering lengths or the pion-nucleon sigma-term are fundamental quantities characterizing the explicit breaking of chiral symmetry by means of the light quark masses. On the other hand, pion-nucleon dynamics also strongly affects the long-range part of nucleon-nucleon potentials, and hence has a far-reaching impact on nuclear physics. I will discuss the fruitful combination of dispersion-theoretical methods, in particular in the form of Roy-Steiner equations, with chiral dynamics to determine pion-nucleon scattering amplitudes at low energies with high precision.

Plenary Session /

The legacy of the experimental hadron physics programme at COSY

WILKIN, Colin[1]

[1]University College London

Corresponding Author(s): c.wilkin@ucl.ac.uk

The hadronic physics programme at the cooler synchrotron and storage ring (COSY) of the Forschungszentrum Juelich terminated at the end of 2014. This talk attempts to review the major achievements in the field realised over the twenty years of intense research activity. This includes the evidence for dibaryons seen in two-pion production, which was backed up by measurements of the analysing power in np elastic scattering, a completely revolutionised pp elastic scattering database, the measurement of the η mass with unparalleled precision and the direct measurement of the η' width, the study of the $\eta' p$ interaction and the clearest evidence for a possible ${}^{3}_{\eta}$He mesic nucleus, the first full amplitude analysis in single pion production, the proof of the $K^- p$ attraction from K^+K^- production, confirmation of the importance of the higher N^* in the $pp \to K^+\Lambda p$ reaction, and the unambiguous evidence for a cusp in the Λp distribution at the ΣN threshold.
*Sponsored by the European Physical Journal

Plenary Session /

Recent result from the A2 collaboration at MAMI

THOMAS, Andreas[1]

[1]Institut für Kernphysik

for the A2 Collaboration

Corresponding Author(s): thomas@kph.uni-mainz.de

The A2 Collaboration at the Mainz Microtron MAMI is measuring photon absorption cross section using circularly and linearly polarized photons up to energies of 1.5GeV.

The photons are produced in the 'Bremsstrahlungs' process, the energy is determined by a dedicated tagging system. The Crystal Ball/ TAPS detector system with its high capability to cope with multi photon final states is used to acquire data with a variety of nonpolarized and spin polarized targets. Physical goals are the investigation of the nucleons excitation spectrum via single and double meson photoproduction and in addition a detailed determination of meson decays in precision experiments. In this talk recent results from A2 Collaboration will be presented.

Plenary Session /

Modelling glueballs

GIACOSA, Francesco[1]

[1]UJK Kielce

Corresponding Author(s): fgiacosa@ujk.edu.pl

Glueballs, i.e. bound states of gluons, were predicted since the early days of Quantum Chromodynamics. They are expected to exist because gluons interact strongly with themselves ('gluons shine in their own light'). Indeed, within Lattice QCD a full spectrum of glueballs has been obtained. The lightest glueball is predicted to be a scalar state and has a mass about 1.7 GeV: as a consequence, intensive research concentrated on the resonances $f_0(1500)$ and $f_0(1710)$ as possible glueball candidates. However, for other quantum numbers, the situation is much less clear: future experimental results and theoretical work are needed in order to identify candidates and in order to study their decay properties. In this talk, we review the theoretical status of glueball's research: different models are compared, both for what concerns the scalar glueball and the other quantum numbers. The role of mixing of glueballs with ordinary quark-antiquark states is addressed. Perspectives for future research on this important subject of hadronic physics are described.

Plenary Session /

ALICE results in pp collisions at 13 TeV

PREGHENELLA, Roberto[1]

[1]CERN and INFN Bologna

for the ALICE Collaboration

Corresponding Author(s): preghenella@bo.infn.it

Results from the ALICE experiment obtained in the second LHC run (Run-2) on charged-particle production will be presented. Charged hadrons emerging from high-energy collisions are dominated by mesons (mainly pions and kaons), being the baryon fraction (mainly protons and antiprotons) lower than about 5% of the total inclusive charged-hadron production. The pseudorapidity and transverse momentum distributions of charged-particles are measured at midrapidity in pp collisions at $\sqrt{s} = 13$ TeV. The evolution of the transverse momentum spectra of charged particles is also investigated as a function of event multiplicity. The results are compared to Monte Carlo models commonly used to describe high-energy hadron interactions.

Parallel Session A3 /

A progress on formulating Bethe-Salpeter kernels

Author(s): QIN, Sixue[1]
Co-author(s): ROBERTS, Craig[1]

[1]ANL

Corresponding Author(s): sqin@anl.gov

We study mesons through solving the coupled system of the gap equation for the quark propagator and the Bethe-Salpeter equation for the meson wavefunction. The gap equation and Bethe-Salpeter equation are in fact members of infinitely coupled Dyson-Schwinger equations of Green functions of QCD. To make it solvable, the system must be truncated. The simplest rainbow-ladder truncation is widely used but shows drawbacks in many aspects. To improve the simplest truncation, we analyze symmetries of the fundamental theory and solve the corresponding Ward-Green-Takahashi identities. Then, the elements of the coupled system, i.e., the quark-gluon vertex and the quark-antiquark scattering kernel, can be constructed accordingly.

Parallel Session A3 /

Status of ChPT calculations in the light meson sector

PASSEMAR, Emilie[1]

[1]Indiana University/JLab

Corresponding Author(s): epassema@indiana.edu

Chiral effective field theory represents a crucial tool for hadronic physics, in particular in combination with dispersion relations. We will review both techniques and present some applications to the light meson sector.

Parallel Session A3 /

Dalitz Plot of $\eta' \to \eta\pi^+\pi^-$

Author(s): GHOSH, Sudeep[1]
Co-author(s): ROY, Ankhi[1]

[1]Indian Institute of Technology Indore, Khandwa Road, Simrol, M.P - 452020, India.

for the CLAS Collaboration Collaboration

Corresponding Author(s): phd12115113@iiti.ac.in

In this talk we present preliminary experimental results of Dalitz plot analysis of the decay $\eta' \to \eta\pi^+\pi-$, based on the CLAS data collected during photoproduction experiment $\gamma p \to \eta'$ p for the center-of-mass energy from 1.9 to 3.34 GeV at Jefferson Lab. This experiment will enable us to report precise Dalitz plot parameters of $\eta' \to \eta\pi^+\pi-$ decay with higher statistics in comparison to other experiments reported so far.

Parallel Session A3 /

Exclusive ω meson production at COMPASS

NOWAK, Wolf-Dieter[1]

[1]Mainz university

for the COMPASS Collaboration

Corresponding Author(s): wolf.dieter.nowak@googlemail.com

The COMPASS collaboration has measured exclusively produced ω mesons in muon proton scattering using a transversely polarised NH_3 target. Five single-spin and three double-spin azimuthal asymmetries in the cross section were determined in the kinematic region 1 to 10 $(\mathrm{GeV/c})^2$ of photon virtuality, 0.003 to 0.3 of Bjorken-x and 0.05 to 0.5 GeV/c of ω squared transverse momentum. The asymmetries are sensitive to nucleon-helicity flip GPDs E^f that are related to orbital angular momentum of flavour f quarks, to chiral-odd GPDs H_T^f that are related to transversity PDFs, and also to the sign of the $\pi\omega$ transition form factor. The results are compared to recent calculations of a GPD-based model.

Parallel Session B3 /

Light meson decays in CLAS and CLAS12

KUNKEL, Michael[1]

[1]Forschszentrum Jülich

for the CLAS Collaboration Collaboration

Corresponding Author(s): m.kunkel@fz-juelich.de

Photoproduction experiments with the CEBAF Large Acceptance Spectrometer CLAS at the Thomas Jefferson National Facility produce data sets with competitive statistics of light mesons. With these data sets, measurements of transition form factors for η, ω, and η' mesons via conversion decays can be performed using the invariant mass distribution of the final state dileptons. Tests of fundamental symmetries and information on the light quark mass difference can be performed using a Dalitz plot analysis of the meson decay. An overview of preliminary results, from existing CLAS data, and future prospects within the newly upgraded CLAS12 apparatus are given.

Parallel Session B3 /

K-Long facility for JLab and its scientific potential

STRAKOVSKY, Igor[1]

[1]The George Washington University

for the GlueX Collaboration

Corresponding Author(s): igor@gwu.edu

Our main interest in creating a secondary high-quality KL beam is to investigate hyperon spectroscopy through both formation and production processes. We propose to study two-body and quasi-two-body reactions induced by the KL beam on the proton target. The experiment should measure both differential cross sections and self-analyzed polarizations of the produced Lambda-, Sigma-, and Xi-hyperons using the GlueX detector at the Jefferson Lab Hall D. New data will greatly constrain partial-wave analysis and reduce model-dependent uncertainties in the extraction of strange resonance properties, providing a new benchmark for comparisons with QCD-inspired models and LQCD calculations. The measurements will span CM \cos\theta from -0.95 to 0.95 in CM range above W = 1490 MeV and up to 4000 MeV.

Parallel Session B3 /

Kaon photoproduction off proton

SKOUPIL, Dalibor[1] ; BYDZOVSKY, Petr[1]

[1]Nuclear Physics Institute, Czech Academy of Sciences, Rez, Czech Republic

Corresponding Author(s): skoupil@ujf.cas.cz

An isobar model for photoproduction of kaons on the proton was recently constructed [1] utilizing new experimental data from CLAS, LEPS and GRAAL collaborations. Higher-spin nucleon (3/2 and 5/2) and hyperon (3/2) resonances were included using

the consistent formalism by Pascalutsa and found to play an important role in data description.
The set of chosen nucleon resonances agrees well with the set of the most probable contributing states determined in the Bayesian analysis with the Regge-plus-resonace model [2]. Particularly, we confirm that the missing resonances $P_{13}(1900)$ and $D_{13}(1875)$ play an important role in the description of data. However, the spin-1/2 state $P_{11}(1880)$ included in the Bayesian analysis was in our analysis replaced by the near-mass spin-5/2 state $N^*(1860)$, recently considered by the Particle Data Group.
In our analysis, a close attention was paid to the model predictions of the cross sections at small kaon angles that are important for accurate calculations of the hypernucleus-production cross sections. It was shown that the small-angle cross sections dominated by the background part of the amplitude receive main contributions from the spin-1/2 and spin-3/2 hyperon exchanges in combination with the Born terms.
Furthermore, since the contribution of the background part of the amplitude is still not well understood, we have accomplished an analysis of the experimental data with the help of the hybrid Regge-plus-resonance model (with which we worked also earlier [3]). In this framework, only three free parameters are needed for the description of the background and it works well in the resonance region as well as in the high-energy region. In our results with the lowest value of χ^2, which are still preliminary, 6 out of 10 nucleon resonances overlap with the resonances included in the set assigned in the Bayesian analysis.
Results of two versions of the isobar model will be compared with the new version of RPR model and experimental data in the third-resonance region and their properties will be discussed. We put an emphasis on the choice of resonances, the predictions in the forward- and backward-angle region as well as the choice of the hadron form factor and the value of its cutoff parameter.
[1] D. Skoupil, P. Bydzovsky, Phys. Rev. C 93 (2016) 025204
[2] L. De Cruz, T. Vrancx, P. Vancraeyveld, and J. Ryckebusch, Phys. Rev. Lett. 108 (2012) 182002
[3] P. Bydzovsky, D. Skoupil, Nucl. Phys. A 914 (2013) 14

Parallel Session B3 /

ϕ(1020) meson production in nucleus-nucleus collisions at 1.9A GeV: centrality dependence and contribution of ϕ decay to K^- spectra

PIASECKI, Krzysztof[1]

[1]University of Warsaw

for the FOPI Collaboration

Corresponding Author(s): krzysztof.piasecki@fuw.edu.pl

Production of ϕ mesons in nucleus-nucleus collisions around 2A GeV, below 2.6 GeV threshold in nucleon-nucleon system, is a rare process to which non-trivial multi-step channels contribute apart from the Fermi motion effects. The measurements carried out by the FOPI Collaboration at 1.9A GeV for symmetric Al+Al and Ni+Ni systems allow for the first time to investigate the important aspects of the ϕ meson production, namely:
(i) the feeding of the ϕ meson decays to the K^- spectral yield, and
(ii) the centrality dependence of the ϕ meson yield and the ϕ/K^- and ϕ/π^+ ratios.
The results are important for the studies of modifications of the effective masses of kaons inside the collision zone.

A simple two-source model of K^- emission allows to extract the spectra of kaons originating directly from the collision zone, which are ready to be compared to the transport model predictions.

[1] K. Piasecki et al. (FOPI Collaboration), Phys. Rev. C 91, 054904 (2015)
[2] P. Gasik et al. (FOPI Collaboration), Submitted to Eur. Phys. Jour., arXiv:1512.06988
[3] K. Piasecki et al. (FOPI Collaboration), Submitted to Phys. Rev. C, arXiv:1602.04378

Parallel Session C3 /

Studying η-meson decays with WASA-at-COSY

LERSCH, Daniel[1]

[1]Juelich Research Center

for the WASA-at-COSY Collaboration

Corresponding Author(s): d.lersch@fz-juelich.de

The η-meson is a unique tool in a way that it provides access to (rare) decay processes, which allow to probe symmetry breaking phenomena, determine transition form factors or to explore the anomalous sector of QCD.
In order to study those decay processes two data sets have been acquired with the WASA-at-COSY experiment at Forschungszentrum Juelich. A proton beam, provided by the COSY accelerator, is impinged on a liquid deuterium / hydrogen pellet target producing η-mesons via: $pd \to {}^3\mathrm{He}\eta$ and $pp \to pp\eta$. The η-decay products as well as the forward-scattered projectiles are detected within the 4π WASA-at-COSY detector.
A first iteration of measurements was done using the $pd \to {}^3\mathrm{He}\eta$ reaction for the study of the more abundant η-decay channels (such as $\eta \to \pi^+\pi^-\pi^0$) and to setup the framework for a common analysis. The rare η-decay modes (e.g. $\eta \to \pi^+\pi^-e^+e^-$) are studied by using the high-statistics $pp \to pp\eta$ data set.
The analyses of both data sets are dedicated to: The isospin violating decay $\eta \to \pi^+\pi^-\pi^0$; Exploring the box anomaly and dipion final state interactions via the radiative decay $\eta \to \pi^+\pi^-\gamma$; The determination of the electromagnetic transition form factor via the decays $\eta \to e^+e^-\gamma$ and $\eta \to e^+e^-e^+e^-$; Testing C- and CP-violation by studying $\eta \to \pi^0e^+e^-$ and $\eta \to \pi^+\pi^-e^+e^-$.
This talk will give an overview about the status of each analysis.

Parallel Session C3 /

Analysis of the production mechanism of $pK + \Lambda$ in $p + p$ collisions using partial wave analysis

MÜNZER, Robert[1]

[1]Institut für Kernphysik, Goethe Universität Frankfurt

Corresponding Author(s): robert.muenzer@cern.ch

Baryonic resonances play a fundamental role in the understanding of nucleus-nucleus reactions at kinetic energies of few GeV. Using partial wave analysis (PWA) for investigation of exclusive reactions allows to take into account the interference between the intermediate resonant and non-resonant amplitudes that contribute to a certain final state. With this method the coherent production mechanism can be analyzed, that have been considered only be few analyses so far. The method was improved by developing a framework that allows for the simultaneous analysis of seven different data set collected with the COSY-TOF, HADES, DISTO and FOPI experiments for the reaction $p + p \to pK + \Lambda$ measured at kinetic energies varying from 2.14 to 3.5 GeV.
In this analysis the excitation function of the different contributing N^{*+}, in a mass range between 1650 MeV/c^2 and 1900 MeV/c^2, decaying into the Λ^-K^+ channel could be extracted for the first time. Furthermore a study of the the $p - \Lambda$ final state interaction could be carried out.
In this talk the analysis method and the results of a combined analysis are presented.

Parallel Session C3 /

Polarization observables in η and double π production using a polarized parget with the Crystal Ball/TAPS at MAMI

WALFORD, Natalie[1]

[1]University of Basel

for the A2 Collaboration

Corresponding Author(s): natalie.walford@unibas.ch

Recent experiments using the Crystall Ball/TAPS setup at the MAMI accelerator in Mainz, Germany continue to study the properties and the excitation spectrum of the nucleon with meson photoproduction. Electromagnetic excitations of the proton and neutron are essential for understanding their isospin decomposition. The electromagnetic coupling of photons to protons is different than that of neutrons in certain states. Hence, a complete partial wave analysis (PWA) can assist in yielding more information about any reaction, but requires the determination of polarization observables. Polarization observables play a crucial role as they are essential in disentangling the contributing resonant and non-resonant amplitudes, whereas cross-section data alone is not sufficient for separating resonances. Preliminary results of polarization observables (E, T, and F) of η and double π production off a polarized neutron (D-butanol) target will be shown with comparison to predictions of recent multipole analyses. These results will allow for developing the world database.

Parallel Session C3 /

Electromagnetic transition form factor of the η meson with WASA-at-COSY

GOSWAMI, Ankita[1]

[1]Indian Institute of Technology Indore

for the WASA-at-COSY Collaboration

Corresponding Author(s): ankitaorg4@gmail.com

In this work we present a study of the Dalitz decay $\eta \to \gamma e^+ e^-$. The aim of this work is to measure the transition form factor of the η meson. The transition form factor of the η meson describes the electromagnetic structure of the meson. The study of the Dalitz decay helps to calculate the transition form factor of the η meson. When a particle is point-like its decay rate can be calculated within QED. However, the complex structure of the meson modifies its decay rate. The transition form factor is determined by comparing the lepton-antilepton invariant mass distribution with QED. For this study data on proton-proton reaction at a beam energy of 1.4 GeV has been collected with WASA-at-COSY detector at Forschungszentrum Juelich, Germany. In the higher invariant mass region recent theoretical calculations slightly deviate from the fit to the data. We expect better results in the higher invariant mass region than previous measurements. The preliminary results of the analysis will be presented.

Parallel Session A4 /

Commissioning and initial experimental program of the BGOOD experiment at ELSA

LEVI SANDRI, Paolo[1]

[1]INFN - LNF

for the BGOOD Collaboration

Corresponding Author(s): paolo.levisandri@lnf.infn.it

BGOOD is an international collaboration that aims at measurements of observables in photonuclear reactions in the energy range from 1 to 3 GeV. The experimental setup for the BGOOD experiment will be presented. Characteristics of the gamma-ray beam and detector performances will be shown and the initial experimental program will be discussed.

Parallel Session A4 /

Photoproduction of the $f_1(1285)$ meson

SCHUMACHER, Reinhard[1]

[1]Carnegie Mellon University

for the CLAS Collaboration

Corresponding Author(s): schumacher@cmu.edu

The $f_1(1285)$ meson with mass 1281.0 ± 0.8 MeV/c^2 and width 18.4 ± 1.4 MeV (FWHM) was measured for the first time in photoproduction from a proton target using CLAS at Jefferson Lab. Differential cross sections were obtained via the $\eta\pi^+\pi^-$, $K^+\bar{K}^0\pi^-$, and $K^-K^0\pi^+$ decay channels from threshold up to a center-of-mass energy of 2.8 GeV and are compared to model predictions. An amplitude analysis of the $\eta\pi^+\pi^-$ final-state Dalitz distribution is consistent with identification as the axial-vector $J^P = 1^+$ $f_1(1285)$, rather than the pseudoscalar 0^- $\eta(1295)$. The production mechanism is most consistent with s-channel decay of a high-mass N^* state, and not with t-channel meson exchange. Decays of the $f_1(1285)$ to $\eta\pi\pi$ are clearly dominated the intermediate states $a_0^{\pm}(980)\pi^{\mp}$. The branching ratios $\Gamma(a_0\pi(no\bar{K}K))/\Gamma(\eta\pi\pi(all))$, $\Gamma(K\bar{K}\pi)/\Gamma(\eta\pi\pi)$ and $\Gamma(\gamma\rho^0)/\Gamma(\eta\pi\pi)$ were obtained and will be compared to world averages.

Parallel Session A4 /

A data-driven model-independent approach to π^0, η and η' single and double Dalitz decays

Author(s): ESCRIBANO, Rafel[1]
Co-author(s): GONZÀLEZ-SOLÍS, Sergi[1]

[1]Universitat Autònoma de Barcelona

Corresponding Author(s): rescriba@ifae.es

The dilepton invariant mass spectra and branching ratios of the single and double Dalitz decays $P \to l^+l^-\gamma$ and $P \to l^+l^-l^+l^-$ ($P = \pi^0,\ \eta,\ \eta',\ l = e$ or μ), are predicted by means

of a data-driven model-independent approach based on the use of rational approximants applied to π^0, η and η' transition form factor experimental data in the space-like region.

Parallel Session A4 /

Electromagnetic effects on meson production - a "new femtoscopy"?

RYBICKI, Andrzej[1] ; SZCZUREK, Antoni[2]

[1]The Henryk Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences

[2]Institute of Nuclear Physics PAN, Krakow and Rzeszow University, Rzeszow

Corresponding Author(s): andrzej.rybicki@ifj.edu.pl

We review our studies of spectator-induced electromagnetic (EM) effects on charged meson emission in ultrarelativistic heavy ion collisions. These effects are found to consist in the electromagnetic *charge splitting* of pion directed flow as well as very large distortions in spectra and ratios of produced charged mesons (like π^+/π^-, K^+/K^-).
As it emerges from our analysis, such EM effects offer sensitivity to the actual distance d_E between the pion formation zone at freeze-out and the spectator matter. As a result, this gives a new possibility of studying the space-time evolution of dense and hot matter created in the course of the collision. Having established that d_E traces the longitudinal evolution of the system and therefore rapidly decreases as a function of pion rapidity, we investigate the latter finding in view of pion feed-over from intermediate resonance production. As a result we obtain a $first\ estimate\ of\ the\ pion\ decoupling\ time\ from\ EM\ effects$. This we compare to existing HBT data.
We conclude that spectator-induced EM interactions can serve as a new tool for studying the space-time characteristics and longitudinal evolution of the system. This "new femtoscopy" remains completely autonomous and independent from HBT information. We discuss the future perspectives for this activity on the basis of existing and future data from NICA, NA61/SHINE, STAR and ALICE.

Parallel Session A4 /

Studying $\rho - N$ couplings with HADES in pion-induced reactions

SCOZZI, Federico[1]

[1]TU Darmstadt/IPN Orsay

for the HADES Collaboration

Corresponding Author(s): f.scozzi@gsi.de

The High-Acceptance Di-Electron Spectrometer (HADES) operates at the GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt with pion, proton and heavy-ion beams provided by the synchrotron SIS18. HADES results on e^+e^- production in proton-nucleus reactions and in nucleus-nucleus collisions demonstrate a strong enhancement of the dilepton yield relative to a reference spectrum obtained from elementary nucleon-nucleon reactions. These observations point to a strong modification of the in-medium rho spectral function driven by the coupling of the rho to baryon-resonance hole states. However, to scrutinize this conjecture, a precise study of the electromagnetic baryon-resonance transition form factors in the time-like region is mandatory. A promising approach are reactions of the type $\pi - N \to R \to e^+e^-N$, for which no experimental data exist yet. In summer 2014, HADES took data using pion beam on carbon and polyethylene targets.

A large part of the data was taken at a pion beam momentum of 0.69 GeV/c in order to explore the second resonance region and the sub-threshold coupling of the ρ to baryonic resonances. In this talk the preliminary results of inclusive dilepton production and for the exclusive channel $\pi - p \rightarrow e^+e^-n$ will be presented and compared with different model calculations. The evidence for Vector Dominance Meson effects will be pointed out as well as the possibility to get some hints about the resonance contributions using angular distributions of dileptons.

This work has been supported by TU Darmstadt: VH-NG-823, Helmholtz Alliance HA216/EMMI, GSI and IPN Orsay.

Parallel Session B4 /

$a_0(980)$ photoproduction in the coupled channel model

BIBRZYCKI, Łukasz[1] ; KAMIŃSKI, Robert[2]

[1]Pedagogical University of Cracow

[2]Institute of Nuclear Physics PAN, Kraków

Corresponding Author(s): lukasz.bibrzycki@ifj.edu.pl

We contructed the $\gamma p \to p\pi\eta$ S-wave photoproduction amplitudes which, for the first time in the literature, take into account effects of the $K\overline{K}$-$\pi\eta$ interchannel coupling in effective mass region corresponding to the $a_0(980)$ resonance [1]. The principal merit of our approach is that apart from the coupling constants already successfully applied in other analyses [2] and resonance parameters like masses, widhts and branching ratios used in the final state interaction parametrisation [3] we do not engage any new model parameters.
We also calculated the Born amplitudes and cross sections for partial waves P and D. These can give an estimation of the photoproduction cross section of spin 1 and spin 2 $\pi\eta$ resonances like $\pi_1(1400)$ and $a_2(1320)$.
It is important to stress that reliable model of the photoproduction in the $\pi\eta$ channel is essential for proper description of data to be collected by new JLab experiments CLAS12 and GlueX.
Literature:
[1] Ł. Bibrzycki, R. Kamiński, http://arxiv.org/abs/1509.06135
[2] Ł. Bibrzycki and R. Kamiński, Phys. Rev. D87, 114010 (2013)
[3] A. Furman, L. Leśniak, Phys.Lett. B538, 266 (2002)

Parallel Session B4 /

The low-energy role of the $a_0(980)$ and $f_0(980)$ resonances in $\eta \to 3\pi$ decays via the Khuri-Treiman formalism

MOUSSALLAM, Bachir[1]

[1]IPN, Universite Paris-Sud

Corresponding Author(s): moussall@ipno.in2p3.fr

$\eta \to 3\pi$ decays are key processes for the determination of the $u - d$ quark mass difference but the chiral expansion of the amplitude converges slowly inside the physical region and fails to reproduce the recent high accuracy measurements of the Dalitz plot parameters. We reconsider the idea of using the chiral expansion in an unphysical region surrounding the Adler zero, where convergence should be much faster, and to predict the amplitude in the physical region using the Khuri-Treiman dispersive formalism. The usual formalism takes into account elastic $\pi - \pi$ rescattering. We present a simple extension to further channels which enable to implement the effects of the $a_0(980)$ and $f_0(980)$ resonances in the dispersive representation. We show that the influence of these resonances at low energy is not negligible, in particular for the $\eta \to 3\pi^0$ decay.

Parallel Session B4 /

Manifestation of dibaryons and scalar σ mesons in single- and double-pion production in NN scattering

Author(s): PLATONOVA, Maria[1]
Co-author(s): KUKULIN, Vladimir[1]

[1]Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University

Corresponding Author(s): platonova@nucl-th.sinp.msu.ru

New experimental and theoretical evidences of six-quark (dibaryon) resonances in NN system are presented. Excitation of intermediate dibaryons in the processes of single- and double-pion production in NN collisions in the GeV region is considered. In particular, relative contributions of intermediate Δ-isobars and isovector dibaryons in the basic single-pion production reaction $pp \to d\pi^+$ near the $N\Delta$ threshold are investigated. Inclusion of dibaryon resonances is shown to considerably improve the description of experimental data for this reaction, provided the consistent parameterization of the $\pi N\Delta$ vertex in πN and NN scattering is used. Manifestation of the intermediate isoscalar and isovector dibaryon resonances in the double-pion production processes is also studied. The interpretation of the near-threshold enhancement in the reaction $pn \to d(\pi\pi)_0$ (the so-called ABC effect) based on the isoscalar $I(J^P) = 0(3^+)$ dibaryon decay with a scalar σ-meson emission is presented. Further experimental tests for the properties of dibaryon resonances and σ mesons are suggested.

Parallel Session B4 /

Study of coherent pion production in proton-deuteron collisions with polarized beams and target at ANKE-COSY

Author(s): DYMOV, Sergey[1]
Co-author(s): SHMAKOVA, Vera[2]

[1]FZ Juelich

[2]JINR

for the ANKE Collaboration

Corresponding Author(s): s.dymov@fz-juelich.de

Two-body pion production in the interaction of protons with few-nucleon systems is of interest, both from the point of view of studying the reaction mechanism, and from that of determining the structure of light nuclei. The success of microscopic models with explicit Δ-excitation for two-nucleon systems suggests that these models should be tested in the three-nucleon case, where production of Δ is intimately linked to 3N forces.
In general six invariant amplitudes are required to describe the $pd \to {}^3He\pi^0$ reaction, but this number reduce to two at threshold or in the forward/backward directions [2]. The $pd \to {}^3He\pi^0$ and $pd \to {}^3H\pi^+$ reactions have been studied experimentally over many decades and a wealth of data on the differential cross sections and analysing powers has been collected for these processes. However, the double polarisation observables have been explored far less and information on the spin correlations is still very scarce. The ANKE spectrometer equipped with an internal polarised target together with the polarised deuteron beam of COSY provided a unique opportunity to conduct measurements of the transverse spin correlation coefficients in these reactions. These results, obtained at 363 and 600 MeV per nucleon, can be used together with the existing data on the differential cross section and the tensor analysing power T_{20} [2] to extract information on the forward spin amplitudes.
This work is supported by the COSY-FFE program.

[1] J.-F. Germond and C. Wilkin, J. Phys. G 16 (1990) 381
[2] C. Kerboul et al., Phys. Lett. B 181 (1986) 28

Parallel Session B4 /

Partial wave analysis of $\pi\pi$ scattering below 2 GeV

NAZARI, Vahabeddin[1]

[1]INP PAN Cracow

Corresponding Author(s): vahabnazari@gmail.com

In a unitary multi-channel approach, precise determination of $\pi\pi$ scattering amplitudes for D and F waves has been presented. These scattering amplitudes are in the $I^GJ^{PC} = 0^+2^{++}$ sector on the processes of $\pi\pi \to \pi\pi$, 4π, $K\bar{K}$ and $\eta\eta$, likewise in the $I^GJ^{PC} = 1^+3^{--}$ sector on the processes of $\pi\pi \to \pi\pi$, 4π, $\omega\pi$ and $K\bar{K}$ for D and F waves respectively. The amplitudes were refined and re-fitted to the dispersion relations up to 1.1 GeV, and to the experimental data in the effective two pion mass from the threshold to 2.7 GeV and 1.9 GeV for D and F waves, respectively. Old parameterizations did not satisfy the crossing symmetry condition and did not describe the $\pi\pi$ threshold region. Moreover, a satisfactory justification regarding the controversies in the states of f_2 and ρ_3 mesons about their masses and number of states that are taken into account has been discussed and finalized.

Parallel Session C4 /

Measurement of hadron cross sections with the SND detector at the VEPP-2000 e^+e^--collider

DIMOVA, Tatyana[1] ; DRUZHININ, Vladimir[2]

[1]Budker Institute of Nuclear Physics

[2]Novosibirsk State University/BINP

for the SND Collaboration

Corresponding Author(s): druzhinin@inp.nsk.su

During 2010-2013 years the experiments with the SND detector were performed at the VEPP-2000 e^+e^--collider in the energy range 0.3-2.0 GeV. The collected data set corresponds to an integrated luminosity of 70 pb^{-1}. The recent results on hadron cross sections measurements will be presented. These results are important for calculations of the anomalous muon moment (g-2) and the fine structure constant α.

Parallel Session C4 /

New e^+e^- accelerators at the energy frontier

SOPICKI, Pawel[1]

[1]INP PAS

Corresponding Author(s): pawel.sopicki@cern.ch

The elucidation of new theories, comprising extensions of the Standard Model, calls unequivocally for the construction of a new electron-positron collider, collecting data at the energy frontier. A comparison of linear versus circular machine concepts for future e^+e^- colliders is presented along with the proposed experiments and summary of their physics reach for i.e. Higgs sector measurements and new phenomena searches.

Parallel Session C4 /

Theoretical studies of $e^+e^- \to K^+K^-\gamma$ reaction

LEŚNIAK, Leonard[1] ; SILARSKI, Michal[2]

[1]Henryk Niewodniczanski Institute of Nuclear Physics PAN

[2]LNF INFN Frascati

Corresponding Author(s): leonard.lesniak@ifj.edu.pl

The $e^+e^- \to K^+K^-\gamma$ reaction is studied for the e^+e^- energies close to the mass of the $\phi(1020)$ meson. Different mechanisms leading to the final state are considered. The strong interaction amplitudes of the K^+K^- pairs in the S-wave are taken into account. Photon emission in the initial state, the final state radiation effects as well as all possible interference terms are included in the transition matrix elements. The K^+K^- effective mass distributions and the angular dependence of the reaction cross-section are calculated. The results of theoretical calculations can be used in future experimental measurement of the unknown branching fraction of the $\phi(1020)$ meson into the $K^+K^-\gamma$ channel. They can also serve in determination of the K^+K^- threshold parameters of the strong interaction amplitudes and in a better specification of the properties of the scalar meson resonances $f_0(980)$ and $a_0(980)$.

Parallel Session C4 /

Low-energy hadronic cross sections measurements at BaBar, and implication for the $g-2$ of the muon

LUKIN, Peter[1]

[1]Budker Institute of Nuclear Physics and Novosibirsk State University

for the BaBar Collaboration

Corresponding Author(s): p.a.lukin@inp.nsk.su

The BABAR Collaboration has an intensive program studying hadronic cross sections at low-energy e^+e^- annihilations, accessible via initial-state radiation. These measurements allow significant improvements in the precision of the predicted value of the muon anomalous magnetic moment. We report here the results of recent studies on a number of processes, with pions and kaons in the final state, obtained with the full BaBar data set

Parallel Session C4 /

PWA with full rank density matrix of the $\pi^+\pi^-\pi^-$ and $\pi^-\pi^0\pi^0$ systems at VES setup

KACHAEV, Igor[1]

[1]IHEP, Institute for High Energy Physics, Protvino, Russia

for the VES, IHEP, Protvino Collaboration

Corresponding Author(s): igor.katchaev@ihep.ru

Partial Wave Analysis of the $\pi^+\pi^-\pi^-$ and $\pi^-\pi^0\pi^0$ systems produced by 28 GeV/c π^- beam on berillium target is presented. About $30 \cdot 10^6$ events for the first one and $16 \cdot 10^6$ events for the second one are collected with VES setup. The statistics for 3π neutral is known to be the largest in the word while statistics for 3π charged is next to largest. The t' range for the analysis is $0 < |t'| < 0.8$ GeV^2/c^2. The data are analyzed using formalism of full rank density matrix. The comparison of the analysis results for two systems is presented.

Plenary Session /

Search for electric dipole moments in storage rings

LENISA, Paolo[1]

[1]University of Ferrara and INFN

for the JEDI Collaboration

Corresponding Author(s): lenisa@fe.infn.it

An electric dipole aligned along the spin axis of a fundamental particle, nucleus, or atomic system violates both parity conservation and time reversal invariance. The observation of such a phenomenon would, at present or proposed levels of experimental sensitivity, signal new physics beyond the Standard Model.
The usual method for identifying an electric dipole moment (EDM) in such searches is to observe the rotation of the spin axis or polarization under the influence of a strong electric field. The use of a storage ring opens the search to charged, polarized particles such as the proton, deuteron, 3He, etc. that would otherwise not be manageable in such a field. The best procedure begins with the alignment of the beam polarization along the velocity of the beam followed by the observation of any slow rotation of that polarization into the vertical direction perpendicular to the ring. Electric ring fields of the right strength or the correct combination of electric and magnetic ring fields are needed to ensure that the polarization does not rotate relative to the velocity ("frozen" spin). This imposes several feasibility requirements. First, the ring must utilize a special combination of higher order fields to ensure that the usually unstable polarization along the direction of the velocity remains for times up to 1000 s to allow any EDM effect to accumulate to a measurable level. Second, the beam must be slowly sampled during the storage time by a polarimeter capable of detecting a change in the vertical polarization of several μrad over the 1000 s storage time. The required large polarimeter efficiency and polarization sensitivity may be achieved by continuously extracting the beam onto a carbon target several cm thick.
Dedicated studies are presently performed at the COSY Storage Ring at FZ-Juelich. Recently it was successfully demonstrated the use of higher-order (sextupole) fields in the storage ring to lengthen the coherence time of the stored, horizontal beam polarization. In addition, unprecedented precision in the measurement of spin-tune has been reached allowing the implementation of a control system for the phase of the spin-precessing beam.
This presentation is meant to provide a general introduction to the EDM search by means of polarized beams in storage rings and to highlight the developments at the COSY ring towards the first direct measurement of the deuteron EDM.

Plenary Session /

The GlueX experiment at Jefferson Lab

MEYER, Curtis A.[1]

[1]Carnegie Mellon University

for the GlueX Collaboration

Corresponding Author(s): cmeyer@cmu.edu

The GlueX Experiment at Jefferson Lab has just completed its commissioning runs and is poised to start physics running in the fall of 2016. All detector elements are now working

very close to design specifications and early physics analyses have been started. I will present an overview of the GlueX physics program as well as the very early analyses. Detector performance will be discussed and preliminary results will be presented.

Plenary Session /

Double polarisation experiments in meson photoproduction

HARTMANN, Jan[1]

[1]University of Bonn

for the CBELSA/TAPS Collaboration

Corresponding Author(s): hartmann@hiskp.uni-bonn.de

One of the remaining challenges within the standard model is to gain a good understanding of QCD in the non-perturbative regime. A key step towards this aim is baryon spectroscopy, investigating the spectrum and the properties of baryon resonances. To gain access to resonances with small πN partial width, photoproduction experiments provide essential information. Partial wave analyses need to be performed to extract the contributing resonances. Here, a complete experiment is required to unambiguously determine the contributing amplitudes. This involves the measurement of carefully chosen single and double polarization observables.
In a joint endeavor by JLab, MAMI, and ELSA, a new generation of experiments with polarized beams, polarized proton and neutron targets, and 4π particle detection have been started in recent years. Many results of unprecedented quality were recently published by all three experiments, and included by the various partial wave analysis groups in their analyses, leading to substantial improvements, e.g. a more precise determination of resonance parameters. In this talk, an overview of recent results in non-strange reactions is given, and their impact on our understanding of the nucleon excitation spectrum is discussed.

Plenary Session /

The antiproton physics program of the $\bar{\mathrm{P}}$ANDA experiment

GIANOTTI, Paola[1]

[1]INFN - LNF

for the $\bar{P}$ANDA Collaboration

Corresponding Author(s): paola.gianotti@lnf.infn.it

The understanding of the QCD in the non perturbative regime, is one of the key issue to have a complete picture of the strong interactions. Recent findings of new and unexpected resonances, with unresolved properties, show that the hadron spectrum is not yet completely understood. This is also underlined by the ongoing discussion on multi-quark states, and on other exotic states with gluonic degrees of freedom.
The $\bar{P}$ANDA experiment, one of the biggest enterprises at the FAIR facility, aims at exploring this field thanks to the gluon rich environment offered by antiproton annihilations.
The a general overview of the $\bar{P}$ANDA physics program will be given in the talk.

Plenary Session /

Hadronic inputs to the $(g-2)_\mu$ puzzle

REDMER, Christoph Florian[1]

[1]Johannes Gutenberg-University Mainz

Corresponding Author(s): redmer@uni-mainz.de

The anomalous magnetic moment of the muon $(g-2)\mu$ is one of the most precisely studied observables of the Standard Model. However, there is a long standing discrepancy of three to four standard deviations between its value obtained from direct measurements and the Standard Model prediction. Since the deviation might hint at physics beyond the Standard Model, new experiments are planned to measure $(g-2)_\mu$ with even better accuracy.
The theory prediction of $(g-2)_\mu$ consists of three main parts, taking into account the effects of QED, weak, and strong interactions. While QED and weak contributions can be described by perturbative means to very high accuracy, the contributions of the strong interaction currently dominate the error of the Standard Model prediction. To increase their precision, experimental information is needed as input. The largest hadronic contribution is due to the hadronic Vacuum Polarization. It can be related to the measurement of the inclusive hadronic cross sections in e^+e^- annihilation. The second largest hadronic contribution stems from hadronic Light-by-Light scattering. It cannot be easily related to measurable quantities and has been evaluated based on hadronic models. Recently data driven approaches based on dispersion relations have been proposed. In both cases transition form factors of pseudoscalar mesons are needed as experimental input.
In this presentation we will discuss recent and future measurements of relevant hadronic cross sections and transition form factors.

Plenary Session /

The overview of the recent results of the hadronic cross sections measurement with the CMD-3 detector at e+e- collider VEPP-2000

FEDOTOVICH, Gennady[1]

[1]Budker Inasitute of Nuclear Physics, Novosibirsk, Russia

for the CMD-3 Collaboration

Corresponding Author(s): fedotovich@inp.nsk.su

The CMD-3 detector collected data since December 2010 at the electron-positron collider VEPP-2000. The data sample corresponds to about 60 inverse picobarn of integrated luminosity collected in the c.m. energy range from 0.32 up to 2 GeV. The measurement of the integrated luminosity is based on two QED processes: $e^+e^- \to e^+e^-$ and $\gamma\gamma$, that provided the systematic accuracy in luminosity smaller 1%. The overview of the recent results of the analysis of various hadronic cross sections are presented for the processes such as: $e+e- \to 3(\pi^+\pi^-)$, $2(\pi^+\pi^-\pi^0)$, $2(\pi^+\pi^-)\pi^0$, $2(\pi^+\pi^-)$, $\pi^+\pi^-2\pi^0$, $\pi^+\pi^-\pi^0$, K^+K^-, K_SK_L, $K^+K^-\eta$, $K^+K^-\omega$, $K^+K^-\pi^+\pi^-$, $\pi^+\pi^-$ and others. The processes with multihadron events in final state have several intermediate states, which must be taken into account to correctly describe the angular and invariant mass distributions as well as the cross section dependence versus energy.

Plenary Session /

Status of the MESA project

AULENBACHER, Kurt[1]

[1]Institut für Kernphysik der Johannes Gutenberg-Universität Mainz

Corresponding Author(s): aulenbac@kph.uni-mainz.de

The Mainz Energy-recovering Superconducting Accelerator (MESA) is a high intensity recirculating linear accelerator in the hundred MeV Range. Beam energy recovery at currents of 1mA or even more enables high luminosities with windowless gas targets. Since each beam particle passes the target only once stationary conditions are achieved, yielding optimum background conditions. Experiments cover, for instance, precision measurements of ground state properties, and searches for dark particles. The talk addresses the layout of the upcoming facility and concentrates on the challenges in accelerator physics.

Plenary Session /

Jefferson Lab 12 GeV Upgrade and CLAS12 Science Program

ELOUADRHIRI, Latifa[1]

[1]Jefferson Lab

Corresponding Author(s): latifa@jlab.org

In the 12 GeV era, Hall B houses the CEBAF Large Acceptance Spectrometer (CLAS12), which is part of the Jefferson Lab 12 GeV upgrade project. For the foreseeable future, CLAS12 will be the only large acceptance detector available worldwide for use in electron scattering experiments. Its mission is to break new ground in our understanding of the complex structure of the nucleon and nuclei, as well as the formation of hadrons and their properties. CLAS12 consists of two large detector systems operating in concert: a forward one based on a new superconducting torus magnet and a central one with a new superconducting solenoid magnet.
After a brief description of the facility I will summarize the scientific opportunities for utilization of CLAS12. I will focus on the study of three-dimensional imaging of the nucleon via studies of the Generalized Parton Distributions (GPDs) and Transverse Momentum Dependent (TMD) parton distributions. The extended kinematic range and new experimental hardware associated with the Jefferson Lab 12 GeV upgrade will provide access to these fundamental underlying distributions and reveal new aspects of nucleon structure. I will present the talk in the context of the recent dedicated experiments to study GPDs and TMDs at 6 GeV from one end and the prospects of the future Electron Ion Collider from the other.

Public Lecture /

The wave of the century. The search for gravitational waves: the history, the discovery, the future.

Corresponding Author(s): eugenio.coccia@lngs.infn.it

Poster Session /

J-PET detector system for studies of the electron-positron annihilations

PAWLIK-NIEDŹWIECKA, Monika[1] ; KHREPTAK, Oleksandr[1] ; MOSKAL, Paweł[1]

[1]Jagiellonian University

for the J-PET Collaboration

Corresponding Author(s): monika.pawlik@uj.edu.pl, alexander.khreptak@gmail.com, p.moskal@uj.edu.pl

J-PET detector has been recently constructed at the Jagiellonian University. It is optimized for the measurement of momentum and polarization of photons from the electron-positron annihilations. It is built out of strips of organic scintillator, forming a cylinder. Light signals from each strip are converted to electrical signals by photomultipliers placed at opposite ends of the strip. The signals are probed in the voltage domain with the accuracy of about 30 ps by a newly developed multithreshold digital electronics and the data are collected by the novel trigger-less and reconfigurable data acquisition system. The geometry and properties of the J-PET detector enable to design the positronium source such that the vector polarization of produced ortho-positronium can be determined. J-PET enables also determination of the polarization of registered photons. Poster will include the description of J-PET detector and its possibilities to determine polarization of ortho-positronium atoms and polarization of photons.
J-PET: P. Moskal et al., Nucl. Instrum. Meth. A764 (2014) 317.
J-PET: M. Pałka et al., Bio-Algorithms and Med-Systems 10, 41 (2014)
J-PET: G. Korcyl et al., Bio-Algorithms and Med-Systems 10, 37 (2014).
J-PET: D. Kamińska et al., Nukleonika 60 (2015) 729.
J-PET: P. Moskal et al., Nucl. Instrum. Meth. A775 (2015) 54.
J-PET: P. Moskal et al., Acta Phys.Polon. B47 (2016) 509.
J-PET G. Korcyl et al., Acta Phys. Pol. B 47 (2016) 491
J-PET: A. Gajos et al., Nucl. Instrum. Meth. A819 (2016) 54.
J-PET: O. Khreptak, M. Pawlik-Niedźwiecka, D. Alfs, T. Bednarski, P. Białas, E. Czerwiński, K. Dulski, A. Gajos, B. Głowacz, D. Kamińska, G. Korcyl, T. Kozik, N. Krawczyk, E. Kubicz, M. Mohammed, Sz. Niedźwiecki, Z. Rudy, M. Silarski, A. Wieczorek, M. Zieliński (Jagiellonian U., Cracow), C. Curceanu (LNF Frascati), M. Gorgol, B. Jasińska, B. Zgardzińska (Maria Curie U., Lublin), B.C. Hiesmayr (Vienna U.), P. Kowalski, W. Krzemień, L. Raczyński, W. Wiślicki (NCBJ, Swierk), P. Moskal (Jagiellonian U., Cracow)

Poster Session /

Inclusive reconstruction of hadron resonances in elementary and heavy-ion collisions with HADES

KORNAKOV, Georgy[1]

[1]TU Darmstadt

for the HADES Collaboration

Corresponding Author(s): g.kornakov@gsi.de

The unambiguous identification of hadron modifications in hot and dense QCD matter is one of the important goals in nuclear physics. In the regime of 1 - 2 GeV kinetic

energy per nucleon, HADES has measured rare and penetrating probes in elementary and heavy-ion collisions. The dominating constituents of the matter formed in the collision zone are primordial nucleons. The main creation mechanism of mesons is the excitation and decay of baryonic resonances throughout the fireball evolution. Furthermore, the excitations of baryons make a significant contribution to the dilepton emission but also play an important role in the production of strange particles. The reconstruction of short-lived (˜1 fm/c) resonance states through their decay products is notoriously difficult. We have developed a new iterative algorithm, which builds the best hypothesis of signal and background by distortion of individual particle properties. This allows us to extract signals with signal-to-background ratios below 1%. The transverse momenta, rapidity, invariant mass spectra and angular distributions for different channels have been reconstructed. In this contribution we will demonstrate the performance of the procedure studying inclusive πp and $\pi\pi$ final state in pion- and proton- induced reactions. We will then discuss the respective for Au+Au reactions 1.23 AGeV and will elaborate on the interplay between phase-space effects, apparent mass-shifts and width of the resonances. This work has been supported by TU Darmstadt: VH-NG-823, Helmholtz Alliance HA216/EMMI and GSI.

Poster Session /

Experimental investigation of $dp \to ppn$ reaction at intermediate energies at Nuclotron

Author(s): JANEK, Marian[1]
Co-author(s): TARJANYIOVA, Gabriela[2] ; PIYADIN, S.M.[3] ; KURILKIN, P. K.[3] ; LADYGIN, V. P.[3] ; GURCHIN, Yu. V.[3] ; ISUPOV, A. Yu.[3] ; KARACHUK, J. T.[4] ; KHRENOV, A. N.[3] ; KURILKIN, A. K.[3] ; LIVANOV, A. N.[3] ; MARTINSKA, Gabriela[5] ; REZNIKOV, S. G.[3] ; TEREKHIN, A. A.[3] ; VNUKOV, I. E.[6]

[1]Zilina University, Physics dept., Faculty of electrical engineering, Univerzitna 8215/1, 010 26 Zilina

[2](Zilina University, Physics dept., Faculty of electrical engineering, Univerzitna 8215/1, 010 26 Zilina)

[3]Veksler and Baldin Laboratory of High Energies, Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia

[4]Advanced Research Institute for Electrical Engineering, Splaiul Unirii 313, Bucharest, Romania

[5]Institute of Physics, University of P. J. Shafarik, Park Angelinum 9, 04001 Kosice, Slovakia

[6]Belgorod State University, Pobedy 85, 308015 Belgorod, Russia

for the DSS Collaboration

Corresponding Author(s): janek@fyzika.uniza.sk

There are still discrepancies between theory and experimental data in the polarisation observables of $dp \to ppn$ reaction in the low and intermediate energies, despite of significant process in the development of theoretical models which include three and more nucleon forces and relativistic effects. The data of $dp \to ppn$ reaction have been accumulated at 300, 400 and 500 MeV in the Nuclotron (Dubna, Russia) and partially processed for some kinematic configurations including few in which possible relativistic effects can appear. Kinematic simulation in the framework of ROOT and GEANT4 package have been performed before data processing. Part of the preliminary results are

obtained in the form of energy deposit correlations of the two arms working in coincidence and few in the form of kinematic S curve.

Poster Session /

Status of the analysis for the search of polarization in the antiproton production process

ALFS, Dominika[1]

[1]Institute of Physics, Jagiellonian University, Kraków

for the P-349 Collaboration

Corresponding Author(s): dominika.alfs@student.uj.edu.pl

A wide range of fundamental effects in the hadronic sector can be investigated only by means of controlling the spin degrees of freedom. Even though polarized beams of protons are routinely produced, preparation of polarized antiproton beam still poses a formidable challenge [1].
The way to achieve it would be relatively easy if some polarization is created during the antiprotons production. For the time being there are no experimental studies performed in this direction. However, e.g. in the hyperon production in the collisions of high energy unpolarized protons with an unpolarized target the produced hyperons show a significant degree of polarization [2]. The goal of the P-349 experiment performed at the T11 beamline of the CERN/PS complex is to find out whether also produced antiprotons show polarization [3].
Antiprotons with a momentum spectrum peaked around 3.5 GeV/c were produced by bombarding the solid target with an unpolarized proton beam of momenta equal to about 24 GeV/c. This corresponds to the typical conditions of the antiproton beam production in existent and planned facilities. The degree of antiprotons polarisation will be investigated via the measurement of asymmetry in the direction of the antiprotons elastic scattering on a liquid hydrogen target (in the reaction $\bar{p}p \to \bar{p}p$) in the Coulomb-nuclear interference region with the expected analyzing power A_y equal to about 4.5% [3].
In this presentation the experimental setup wil be presented and the status of the ongoing analysis focused on the track reconstruction and particle indentification will be shown.
[1] E. Steffens, AIP Conf.Proc. 1149, 80-89 (2009)
[2] E. J. Ramberg, Phys. Lett. B 338, 403-408 (1994)
[3] D. Grzonka, et. al., Acta Phys. Polon. B 46 191 (2015)

Poster Session /

Polarization observables in $\gamma p \to K^+\Lambda$ / $K^+\Sigma^0$ using circularly polarized photons on a polarized frozen spin target

WALFORD, Natalie[1]

[1]Catholic University of America

for the CLAS Collaboration

Corresponding Author(s): natalie@jlab.org

The search for undiscovered excited states of the nucleon continues to be a focus of experiments at the Thomas Jefferson National Accelerator Facility (JLab). A large effort was done using the CEBAF Large Acceptance Spectrometer (CLAS) detector to provide the database, which will allow nearly model-independent partial wave analyses (PWA) to be carried out in the search for such states. Polarization observables play a crucial role in the effort, as they are essential in disentangling the contributing resonant and non-resonant amplitudes. Recent coupled-channel analyses have found strong sensitivity of the $K^+ + \Lambda$ channel to several higher mass nucleon resonances. In 2010, double-polarization data were taken at JLab using circularly and linearly polarized tagged photons incident on a longitudinally and transversely polarized frozen spin butanol target (FROST), operated at the temperature of 30 mK. The reaction products were detected in CLAS. This work is based on the analysis of FROST data and the extraction of the T, F, T_x, and T_z asymmetries of the $K^+\Lambda$ and $K^+\Sigma^0$ final states and their comparison to predictions of recent multipole analyses. There are very few published measurements of the T asymmetry and none for the F, T_x, and T_z asymmetries for the $K^+\Lambda$ final state. The $K^+\Sigma^0$ final state has no published measurements for these asymmetries. This work is the first of its kind and will significantly broaden the world database for these reactions.

Poster Session /

Searching for η-mesic ^{3}He with WASA-at-COSY facility

KHREPTAK, Oleksandr[1] ; RUNDEL, Oleksandr[2]

[1]IF Jagiellonian University

[2]IF Jagiellonial University

for the WASA-at-COSY Collaboration

Corresponding Author(s): o.rundel@doctoral.uj.edu.pl

The existence of η-mesic nuclei in which the η meson is bound with nucleus with the strong interaction was postulated by Haider and Liu already in 1986, however till now no experiment confirmed it empirically. Recent theoretical studies of hadronic- and photoproduction of η meson, revealing posibility of existence for η-mesic bound states for light nuclei like ^{3}He, give the hope of their observation in proton-deuteron fusion reactions. Our research group has developed a method giving a chances to discover the $\eta-^3$He bound state. In 2014 we performed measurements using proton beam from COSY synchrotron and the WASA detector installed in the Research Center Jülich in Germany. The main advantage of the used experimental setup is a possibility of continuous changing of beam energy and simultaneous registration of all particles taking part in the reaction. Moreover, we have collected significantly higher statistics in comparison to previous experiments. The data analysis is in progress. The target process of analysis that is $pd \to bound(^3\mathrm{He}\eta)$. It will be searched in $pd \to ^3\mathrm{He}2\gamma$, $pd \to ^3\mathrm{He}6\gamma$, $pd \to ppp\pi^-$ and $pd \to pnn\pi^+$ reactions. The luminosity can be obtained from $pd \to ^3\mathrm{He}\eta$, $pd \to ^3\mathrm{He}\pi^0$ and $pd \to ppn_{spec}$ reactions. The poster will include description of the experimental method used at WASA and the preliminary results of the data analysis.

Poster Session /

Near threshold production of η-mesons in proton neutron collisions at ANKE

Author(s): SCHRÖER, Daniel[1]
Co-author(s): FRITZSCH, Christopher[2] ; KHOUKAZ, Alfons[3] ; RUMP, Marcel[2]

[1]WWU Muenster

[2]WWU Münster

[3]University of Münster

for the ANKE Collaboration

Corresponding Author(s): d_schr13@uni-muenster.de

The interaction between η mesons and hadrons is an intensively investigated topic. Due to its stength it might lead to the formation of η-mesic nuclei. In order to study the characteristics of this interaction a measurement of the reaction $p+d \rightarrow d+\eta+p_{sp}$ has been performed at the ANKE spectrometer at the COSY accelerator of the Forschungszentrum Juelich. In this context the deuteron serves as an effective neuteron target whereas the proton is treated as a spectator particle. The two different beam momenta ($p_1 = 2.09$ GeV/c and $p_2 = 2.25$ GeV/c) in combination with the Fermi motion inside the target deuteron grant access to the determination of total and differential cross sections in an excess energy range from threshold up to $Q = 90$ MeV. While the course of the total cross section, especially near threshold, will allow to compute the scattering length $a_{d\eta}$ of an s-wave final state interaction ansatz, the differential cross sections permit to verify the legitimacy of the s-wave assumption. Furthermore the data taken at higher excess energies enable to examine the role of nucleonic resonances in the production process of η mesons. Recent results will be presented and discussed.
*Supported by the FFE program of the Forschungszentrum Juelich

Poster Session /

New results of the antiproton-carbon annihilation cross section measurement at low energies

MASCAGNA, Valerio[1] ; VENTURELLI, Luca[2] ; LEALI, Marco[2] ; CORRADINI, Maurizio[2] ; LODI-RIZZINI, Evandro[2] ; AGHAI-KHOZANI, Hossein[3] ; HORI, Masaki[3] ; HAYANO, Ryugo[4] ; MURAKAMI, Yohei[4] ; PREST, Michela[5] ; VALLAZZA, Erik[6] ; HIROYUKI, Yamada[4]

[1]Università degli Studi di Brescia - INFN Sezione di Pavia

[2]Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Brescia, 25133 Brescia, Italy & INFN - Pavia, 25133 Brescia, Italy

[3]Max-Planck-Institut fur Quantenoptik, D-85748 Garching, Germany

[4]Department of Physics, University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan

[5]Dipartimento di Scienza e Alta Tecnologia, Università degli Studi dell'Insubria, I-21100 Varese, Italy & INFN - Milano Bicocca, I-20126 Milano

[6]INFN - Trieste, I-34127 Trieste, Italy

Corresponding Author(s): valerio.mascagna@unibs.it

The antinucleon-nuclei annihilation cross section σ_{ann} at very low energy has been measured at the LEAR facility (CERN) during the 80's and 90's and recently at the

Antiproton Decelerator. The antineutron data at momenta below 180 MeV/c on several nuclei showed a steep rise which is expected only for the antiproton projectile due to its negative charge. The difference between the antineutron and the antiproton interaction with nuclei can be investigated measuring the σ_{ann} of the antiprotons on the same nuclei and at the same energies. So far a direct comparison of the σ_{ann} is possible only for momenta below 80 MeV/c (on proton) and at 100 MeV/c (on Sn target). The ASACUSA collaboration recently performed an experiment to measure the σ_{ann} of 100 MeV/c antiprotons on a carbon target whose preliminary results are presented here.

Poster Session /

Finite energy sum rules in hadron spectroscopy

MATHIEU, Vincent[1]

[1]Indiana University

for the Joint Physics Analysis Center Collaboration

Corresponding Author(s): mathieuv@indiana.edu

We'll discuss the relation between Reggeons and resonances. Based on analyticity (dispersion relations), one can formalize this relation into a mathematical statement relating the resonance region to the high energy (Regge) region. One can then use these sum rules to constraints the extraction of resonances from the high energy data. We will illustrate this technique on various processes (Pi-N and K N scattering ; photoproduction of mesons).

Poster Session /

Dependence of mass in comparison to full width of mesons

NEDOLYA, Anatoliy[1]

[1]Zaporizhzhya National University

Corresponding Author(s): avnedolya@hotmail.com

It is known that the lifetime of relativistic particles depends on their energy. For example, the lifetime of muons in cosmic rays increases to $\gamma = (1 - \beta^2)^{-1/2}$ times. Based on uncertainty principle, for the short-lived particles the lifetime is determined from the full width ($\Gamma = \hbar/\tau$) of energy distribution of the decaying particles. Currently the dependence of the lifetime of elementary particle from its mass (rest energy) was not determined, although was established the dependence of the lifetime on the particle from the type of fundamental interaction. We regard the mass of mesons in comparison to their full width (lifetime) using the Review of Particle Physics [1]. Figure shows that most of mesons were located inside range, upper edge of which varied periodically. Maximum values of mass relates to each other as 1, 2, 3, and possibly 6 with a period near to 2 GeV. Any mesons have not been found in mass range from 6300 to 9400 Mev. The estimated range of mass for $f_o(500)$ light unflavored meson does not coincide with a present dependence and should be revised in our opinion. The similar distribution has been obtained for baryons. This uneven distribution of mesons and baryons explains the discrete distribution of the particles' mass and energy in the Universe. The results may be useful to clarify range of mass for the new searching particles.
[1] Olive K.A et al. Review of particle Physics. Chinese Physics C, Vol. 38, No. 9 (2014) 090001.

Poster Session /

Study of the η meson production with the polarized proton beam

Author(s): SCHAETTI-OZERIANSKA, Iryna[1]
Co-author(s): MOSKAL, Pawel[2] ; ZIELIŃSKI, Marcin[2]

[1]Jagiellonian University of Krakow

[2]Jagiellonian University

for the WASA-at-COSY Collaboration

Corresponding Author(s): i.ozerianska@gmail.com

The η meson production process was studied via measurements of the analyzing power, A_y for the $\vec{p}p \to pp\eta$ reaction. The measurement was performed with the WASA-at-COSY detector at excess energies of 15 MeV and 72 MeV. The missing mass and invariant mass techniques were used to identify η meson. The angular distribution of the analyzing power of for the η meson was determined. The result is more than 5 order of magnitude more precise than achieved in previous experiments [1,2]. The result of the studies shows a disagreement between experiment and the predicted theoretical behavior of A_y. The data indicate that at the excess energy of 15 MeV there is no contribution from Sd and Pp partial waves. Thus we prove experimentally for the first time that in the $\vec{p}p \to pp\eta$ reaction the η meson is produced in a s-wave with respect to the protons at least up to 15 MeV. Whereas at an excess energy of 72 MeV contributions from the Pp wave is significant.
[1] R. Czyzykiewicz et al., Phys. Rev. Lett. 98 (2007) 122003.
[2] F. Balestra et al. Phys. Rev. C 69 (2004) 064003.

Poster Session /

Experimental study of three-nucleon dynamics in the dp breakup collisions using the WASA detector

Author(s): KŁOS, Barbara[1]
Co-author(s): CIEPAŁ, Izabela[2]

[1]Institute of Physics, University of Silesia, PL-40007 Katowice, Poland

[2]Institute of Nuclear Physics PAN, PL-31342 Krakow, Poland

for the WASA-at-COSY Collaboration

Corresponding Author(s): barbara.klos@us.edu.pl

An experiment to investigate the $^1\mathrm{H}(d,pp)n$ breakup reaction using a deuteron beam of 340, 380 and 400 MeV and the WASA detector has been performed at the Cooler Synchrotron COSY Julich. The studied energy region, below but close to a pion production threshold, may provide information on various aspects of nuclear interactions, in particular on relativistic effects and their interplay with the three nucleon force ($3NF$). Calculations including various pieces of dynamics like $3NF$ [1], long-range Coulomb interaction [2] or relativistic effects, predict their influence to reveal with different strength at different parts of the breakup reaction phase space. Cross section observables are very sensitive to all of these effects. The calculations in relativistic regime have recently been performed for the $^1\mathrm{H}(d,pp)n$ breakup reaction at the beam energies of 340, 380 and 400 MeV [3], clearly demonstrating importance of relativistic description at these energies. The almost

4π geometry of the WASA detector gives an unique possibility to study interplay of all the effects in the large part of phase space. Currently, the data analysis is focused on the proton-proton coincidences registered in the Forward Detector with the aim to determine the differential cross sections on dense angular grid of kinematical configurations defined by the emission angles of the two outgoing protons: two polar angles θ_1 and θ_2 (in the range between 4^o and 18^o) and the relative azimuthal angle ϕ_{12}. Elastically scattered deuterons are used for precise determination of the luminosity. The main steps of the analysis, including energy calibration, PID and studies of efficiency, and their impact on final accuracy of the result, will be discussed.

[1] W. Glockle et al., Phys. Rep. 274 (1996) 107.
[2] A. Deltuva et al., Phys. Rev. C72 (2005) 054004.
[3] H. Witala, private communication.

Poster Session /

Predictions on the second-class current decays $\tau^- \to \pi^-\eta(')\nu_\tau$

Author(s): ESCRIBANO, Rafel[1]
Co-author(s): GONZÀLEZ-SOLÍS, Sergi[1] ; ROIG, Pablo[2]

[1]Universitat Autònoma de Barcelona

[2]CINVESTAV (México)

Corresponding Author(s): sgonzalez@ifae.cat

We analyze the second-class current decays $\tau^- \to \pi^-\eta(')\nu_\tau$ in the framework of Chiral Perturbation Theory with Resonances. Taking into account $\pi^0 - \eta - \eta'$ mixing, the $\pi - \eta(')$ vector form factor is extracted, in a model-independent way, using existing data on the $\pi - \pi_0$ one. For the participant scalar form factor, we have considered different parameterizations ordered according to their increasing fulfillment of analyticity and unitarity constraints. We start with a Breit-Wigner parameterization dominated by the $a_0(980)$ scalar resonance and after we include its excited state, the $a_0(1450)$. We follow by an elastic dispersion relation representation through the Omnes integral. Then, we illustrate a method to derive a closed-form expression for the $\pi - \eta$, $\pi - \eta'$ (and $K - K^0$) scalar form factors in a coupled-channels treatment. Finally, predictions for the branching ratios and spectra are discussed emphasizing the error analysis. An interesting result of this study is that both $\tau^- \to \pi^-\eta(')\nu_\tau$ decay channels are promising for the soon discovery of second-class currents at Belle-II. We also predict the relevant observables for the partner $\eta(')_{l3}$ decays, which are extremely suppressed in the Standard Model.

Poster Session /

The $\rho(\omega)/B^*(B)$ system and bound states in the unitary local Hidden Gauge approach

Author(s): FERNANDEZ-SOLER, Pedro[1]
Co-author(s): OSET, Eulogio[2] ; NIEVES, Juan Miguel[1] ; SUN, Zhi-Feng[1]

[1]Instituto de Física Corpuscular (IFIC) - University of Valencia

[2]University of Valencia

Corresponding Author(s): pedro.fernandez@ific.uv.es

In this work we study the $\rho(\omega)B^*$ interaction using the local Hidden Gauge approach and a non-perturbative method. We search for poles in the T-matrix formalism, solving the factorized Bethe-Salpeter equation in coupled channels and identifying the different states as ρB^* bound states for all the possible spins, $J = 0, 1, 2$. We fit the parameters of

the theory in order to reproduce the mass and width of an already existing state in the PDG with $I(J^P) = 1/2(2^+)$, the $B_2^*(5747)$, and the $J = 0, 1$ states are then predictions. We also calculate the ρB interaction in the local Hidden Gauge approach, which let us obtain an additional $J = 1$ state that can be identified with another PDG state, the $B_1(5721)$, and then we predict a width for this state. Since in the bottom sector we are considering heavy mesons, we discuss the relevance of Heavy Quark Spin Symmetry, and how it is or not reflected in the present formalism. As a main result in this aspect we mention here that all the states exhibit a near degeneracy in spin, and the leading order terms in the potential in the Heavy Quark Spin Symmetry power counting preserve the spin symmetry. These terms are the corresponding ones to light vector meson exchange in the Hidden Gauge, while the heavy meson exchange and contact terms are suppressed in the heavy quark mass power counting.
Based on "The $\rho(\omega)B^*(\bar{B})$ interaction and states of $J = 0, 1, 2$". Eur. Phys. J. C 76 (2016) 2, 82.

Poster Session /

Central exclusive production of $\rho\rho$ pairs in proton collision

Author(s): TURNAU, Jacek[1]
Co-author(s): KYCIA, Radosław[2]

[1]Institute of Nuclear Physics PAN

[2]Tadeusz Kościuszko Cracow University of Technology

Corresponding Author(s): kycia.radoslaw@gmail.com

We investigate the central exclusive production of $\rho\rho$ pairs in pp collisions at LHC energies. At low central invariant mass this process can be considered as a possible nonresonant background for glueball searches in four-body final states. Above the resonance region nonperturbative production mechanism can be studied. All calculations have been performed using generator GENEX(arXiv:1411.6035 [hep-ph]), specially designed for effective integration of exclusive processes in restricted phase space.

Poster Session /

Thermodynamic instabilities in hot and dense nuclear matter

Author(s): LAVAGNO, Andrea[1]
Co-author(s): PIGATO, Daniele[2]

[1]Politecnico di Torino and INFN (Italy)

[2]Politecnico di Torino (Italy)

Corresponding Author(s): andrea.lavagno@polito.it

We investigate the presence of thermodynamic instabilities in a hot and dense nuclear medium where a phase transition from a gas of massive hadrons to a nearly massless baryon, antibaryon plasma can take place. The analysis is performed by requiring the global conservation of baryon number and zero net strangeness in the framework of an effective relativistic mean field theory with the inclusion of the $\Delta(1232)$-isobars, hyperons and the lightest pseudoscalar and vector meson degrees of freedom. Similarly to the low density nuclear liquid-gas phase transition, we show that such a phase transition is characterized by both mechanical instability (fluctuations on the baryon density) that by chemical-diffusive instability (fluctuations on the strangeness concentration). It turns out that, in this situation, phases with different values of antibaryon-baryon ratios and strangeness content may coexist altering significantly different meson-antimeson ratios.

Poster Session /

A three body state with $J = 3$ in the $\rho B^* \bar{B}^*$ interaction

Author(s): FERNANDEZ-SOLER, Pedro[1]
Co-author(s): OSET, Eulogio[2] ; SUN, Zhi-Feng[3] ; BAYAR, Melahat[4]

[1]Instituto de Física Corpuscular (IFIC). University of Valencia.

[2]University of Valencia

[3]Instituto de Física Corpuscular (IFIC) - University of Valencia

[4]Kocaeli University

Corresponding Author(s): p.fdez.s.90@gmail.com

Motivated by previous works in which the ρB^* and the $B^* \bar{B}^*$ interactions were studied, we calculate the interaction of the three-body system $\rho B^* \bar{B}^*$. We know that the ρB^* interaction in $J = 2$ is stronger than in any other possible spin, and also an attractive interaction was found in the $B^* \bar{B}^*$ system, producing in both cases a bound state. Then we search for a three-body bound state in the $\rho B^* \bar{B}^*$ system assuming that the $B^* \bar{B}^*$ is forming a cluster and letting the lighter ρ meson interact with the B-mesons always in a spin two configuration. This fact justifies the using of the Fixed Center approximation, and considering the $J = 2$ ρB^* interaction we find a $J = 3$ three body meson molecule solving the Faddeev equations. As a consequence of the strongly attractive two-body interaction in the different subsystems , a $J = 3$ three-body state is found, providing a prediction of an exotic state.
Based on "States of $\rho B^* \bar{B}^*$ with $J = 3$ within the Fixed Center Approximation to Faddeev equations" Eur. Phys. J. A in print. arXiv:1510.06570 [hep-ph].

Poster Session /

Three-point Green functions of currents in the odd sector of QCD

Author(s): KADAVY, Tomas[1]
Co-author(s): KAMPF, Karol[1] ; NOVOTNY, Jiri[1]

[1]Charles University in Prague

Corresponding Author(s): tomas.kadavy@gmail.com

A review of familiar results of the three-point Green functions of currents in the odd-intrinsic parity sector of QCD is presented. Such Green functions include very well-known examples of VVP, VAS or AAP correlators. We also present new results for VVA and AAA Green functions that have not yet been studied extensively in the literature before, more importantly with a phenomenological study and a discussion of the high-energy behaviour and its relation to the QCD condensates.

Poster Session /

Production and decay of intermediate dibaryon resonances: implications for chiral symmetry restoration and the nuclear force problem

Author(s): KUKULIN, Vladimir[1]
Co-author(s): PLATONOVA, Maria[1]

[1]Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University

Corresponding Author(s): kukulin@nucl-th.sinp.msu.ru

The review talk covers a few hot topics, all of them being tightly interrelated to production and decay model of intermediate dibaryon resonances predicted theoretically long ago but reliably confirmed in experiments only recently. We will survey shortly both strong rising and subsequent fall down and a recent new renaissance in dibaryon studies. The second topic which will be discussed in detail is the tight interrelation of dibaryon production and the nuclear force problem. It will be argued that many characteristic features of nuclear force, like specific I and J dependence, strong spin-orbit splitting, etc., are intimately interrelated to the intermediate dibaryon production. Still another hot topic in excited hadron structure which will be discussed briefly is the Chiral Symmetry Restoration (CSR) which must play also a key role in EoS for dense/hot nuclear matter. Some discussion will also be devoted to the enhanced dipion and dilepton production at 1 GeV in pn but not in pp collisions. We will also consider some specific features of strong scalar 3N force and EoS in dense nuclear matter.

Poster Session /

Electromagnetic transition form factor and decays of neutral pions

Author(s): HUSEK, Tomáš[1]
Co-author(s): LEUPOLD, Stefan[2] ; KAMPF, Karol[1] ; NOVOTNÝ, Jiří[1]

[1]Charles University in Prague

[2]Uppsala University

Corresponding Author(s): thusek@cern.ch

In this talk we will discuss two important processes of the low-energy hadron physics: the rare decay $\pi^0 \to e^+e^-$ and the Dalitz decay of π^0.
We briefly summarize experimental and theoretical results on the decay $\pi^0 \to e^+e^-$. The analytical two-loop QED corrections together with the bremsstrahlung contribution beyond the soft-photon approximation are reviewed.
Finally, we present the Two-hadron saturation (THS) scenario for the PVV correlator and apply it to the processes under discussion.
The obtained results can be also used in a theoretical calculation of the hadronic light-by-light scattering contribution to the $g-2$ type experiments.

Poster Session /

D-meson observables in $p-$Pb collisions at LHC with EPOSHQ model

Author(s): OZVENCHUK, Vitalii[1]
Co-author(s): AICHELIN, Joerg[2] ; GOSSIAUX, Pol-Bernard[2] ; WERNER, Klaus[2] ; NAHRGANG, Marlene[3]

[1]IFJ PAN

[2]Subatech

[3]Duke University

Corresponding Author(s): ozvenchuk@gmail.com

The first experimental results from pPb collisions at 5 TeV on the particle yields and azimuthal anisotropies as function of transverse momentum show a very similar behavior in comparison to the observations in heavy-ion collisions, where the quark-gluon plasma (QGP) can be produced. Such pPb results have indeed been explained in the framework of models including a QGP phase such as EPOS3. Heavy-flavor particles have been suggested as a good probe to study the properties of the QGP. Heavy quarks (HQ) are produced in the initial hard nucleon-nucleon scatterings and their thermal equilibration time is larger than the QGP lifetime. In this contribution we study the D-meson observables in pPb collisions at 5 TeV as it offers a complementary perspective with respect to light hadrons production.
We calculate the nuclear modification factor of D mesons in pPb collisions using the EPOSHQ model. It couples a Monte Carlo propagation of HQ to the 3+1 dimensional fluid dynamical evolution of the QGP from EPOS3 initial conditions, which combine pQCD calculations of the hard scattering with the Gribov-Regge theory. HQ that in EPOS3 can be produced during the spacelike cascade, the born process and the partonic shower, interact with plasma partons by either elastic or radiative collisions. The HQ form hadrons via coalescence or fragmentation on the hypersurface of constant temperature $T = 155$ MeV.
We further couple our model with UrQMD to study the influence of hadronic rescatterings on heavy-flavor observables in heavy-ion collisions at LHC energies. The cross sections between D mesons and light hadrons used in UrQMD are calculated in effective models including the chiral and heavy-quark-spin symmetries in Lagrangian as well as the exact satisfaction of the unitarity condition of the scattering matrix.

Poster Session /

Mass and width of Δ resonance using complex-mass renormalization scheme

Author(s): UNAL, Yasemin[1]
Co-author(s): SCHERER, Stefan[2] ; BAUER, Torsten[3] ; KUCUKARSLAN, Ayse[4]

[1]Canakkale Onsekiz Mart University

[2]Johannes Gutenberg-Universität Mainz

[3]JGU Mainz

[4]COMU

Corresponding Author(s): yaseminunal@comu.edu.tr

We calculate the pole mass and width of the Δ resonance to the third order in chiral effective field theory. We choose the complex-mass renormalization scheme in our calculation and compare the convergence behavior of both the complex-mass scheme (CMS) and the small-scale expansion (SSE) calculating the loop contributions to the

delta resonance mass. Contributions of the renormalized loop diagrams for real and imaginar part of the pole of delta resonance are represented graphically depending on the pion mass. We show that a consistent power counting scheme can be obtained within the CMS, independently of counting the mass difference $\delta = m_\Delta - m_N$ as a small quantity of chiral order q as in the SSE.

Poster Session /

Contribution of three nucleon force investigated in deuteron-proton breakup reaction

PAROL, Wiktor[1]

[1]Institute of Nuclear Physics Polish Academy of Science, Krakow, Poland

for the Few Body Group Collaboration

Corresponding Author(s): wiktor.parol@ifj.edu.pl

Investigation of three-nucleon systems is important for testing nuclear potentials. Quantitatively, it can be done by comparing observables calculated with the use of Faddeev equations with the results of precise measurements. Modern realistic nucleon-nucleon (NN) potentials describe well two nucleon systems. They are successfully applied to predict observables of deuteron-proton breakup reaction only if combined with additional elements of the dynamics like the three nucleon force (3NF). Moreover, the two- and three-nucleon interactions can be modelled within the coupled-channel (CC) framework by an explicite treatment of the Δ-isobar excitation. In Chiral Perturbation Theory, the few-body interactions appear naturally at growing orders (non-vanishing 3NF at next-to-next-to leading order). The modern approaches to calculate observables for 3N system include , besides NN potentials and 3NF contribution, also, Coulomb interactions [1] or relativistic component [2]. All the effects are predicted to influence observables with different magnitude and in various parts of phase space of the breakup reaction, what can be verified by comparison with experimental data.
Experiments devoted to study nuclear dynamics by measurement of the 1H(d,pp)n breakup reaction were carried out at KVI Groningen [3, 4] and FZ-Juelich [4, 5] with the deuteron beam at the wide range of intermediate energies. Poster focuses on measurement done at KVI with unpolarised deuteron beam of 80˜MeV/nucleon energy impinging on liquid hydrogen target. Differential cross-sections for deuteron-proton breakup reaction was determined for a number of kinematic configurations of outgoing particles. Normalization was obtained on the basis of the elastic scattering process. The main steps of the data analysis including geometry cross-check, energy calibration, particles identifications and reconstructed kinematics as well as sample distributions of the normalized differential cross-sections for deuteron breakup.
[1] A. Deltuva A. C. Fonseca, and P. U. Sauer, Phys. Rev. C 73 057001 (2006)
[2] H. Witała R. Skibinski and J. Golak, The European Physical Journal, A30:369 (2006)
[3] St. Kistryn et al., Phys. Lett. B 641, 23 (2006)
[4] B. Kłos et al., Acta Phys. Pol., B 44, 3 (2013)
[5] I. Ciepał et al., Few-Body Syst., 56, 10 (2015)

Poster Session /

The role of an h_1 state in the $J/\psi \to \eta K^{\star 0}\bar{K}^{\star 0}$ decay

Author(s): XIE, Ju-Jun[1]
Co-author(s): OSET, Eulogio[2] ; ALBALADEJO, Miguel[2]

[1]Institute of Modern Physics, CAS

[2]IFIC, Valencia, Spain

Corresponding Author(s): xiejujun@impcas.ac.cn

The BES data on the $J/\psi \to \eta K^{\star 0}\bar{K}^{\star 0}$ reaction show a clear enhancement in the $K^{\star 0}\bar{K}^{\star 0}$ mass distribution close to the threshold of this channel. Such an enhancement is usually a signature of a L=0 resonance around threshold, which in this case would correspond to an h_1 state with quantum numbers $I^G(J^{PC}) = 0^-(1^{+-})$. A state around 1800 MeV results from the interaction of the $K^\star\bar{K}^\star$ using the local hidden gauge approach. We show that the peak observed in $J/\psi \to \eta K^{\star 0}\bar{K}^{\star 0}$ naturally comes from the creation of this h_1 state with mass and width around 1830 MeV and 110 MeV, respectively. A second analysis, model independent, corroborates the first result, confirming the relationship of the enhancement in the invariant mass spectrum with the h_1 resonance.

Poster Session /

Invariant variables for breakup reaction

Author(s): SKWIRA-CHALOT, Izabela[1]
Co-author(s): CIEPAŁ, Izabela[2]

[1]Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland

[2]Institute of Nuclear Physics PAS, Radzikowskiego 152, 31-342 Kraków, Poland

Corresponding Author(s): izabela.skwira@fuw.edu.pl

A large set of high precision data of ${}^1H(\vec{d}, pp)n$ reaction at beam energy of 130 MeV were collected with SALAD and GeWall detectors. The polarized deuteron beams were produced with the use of the ion sources of the AGOR (KVI Groningen, The Netherlands) and COSY (IKP FZ-Juelich, Germany) accelerators, respectively.
The $\vec{d}p$ breakup reaction is one of the simplest processes to study dynamics of three nucleons. The process is characterised by a rich kinematics of the final state what makes it selective regarding the employed model of interaction. Experiments with polarized beams (or targets) give opportunity to study a large number of observables (e.g. analyzing powers) sensitive to dynamical components, which are hidden in the unpolarized case. All studied observables (e.g. cross section, vector and tensor analysing power) are interesting for testing theoretical calculations based on various approaches to model the interaction in few-nucleon systems.
The kinematics of breakup reaction can be described in many different ways, e.g. using particles energies and their emission angels, with Jacobi momenta or in terms of invariant variables. In this work we concentrate on the Mandelstam variables which have been rewritten in a convenient way for breakup reaction (three-nucleon in final state).
The experimental data will be transformed to the variables based on Lorentz-invariants and compared with modern theoretical calculations. The main purpose of such analysis is to check its applicability for studies of various dynamical effects. In particular, studies in terms of invariant variables can encompass and treat in a consistent way very rich data sets collected for breakup reaction at various energies.

Poster Session /

Perspective study of charmonium, exotics and baryons with charm and strangeness

Author(s): BARABANOV, Mikhail[1]
Co-author(s): VODOPYANOV, Alexander[1]

[1]JINR

Corresponding Author(s): barabanov@jinr.ru

The spectroscopy of charmonium-like states together with the spectroscopy of charmed and strange baryons is discussed. It is a good testing tool for the theories of strong interactions, including: QCD in both the perturbative and non-perturbative regimes, LQCD, potential models and phenomenological models [1, 2, 3]. An understanding of the baryon spectrum is one of the primary goals of non-perturbative QCD. In the nucleon sector, where most of the experimental information is available, the agreement with quark model predictions is astonishingly small, and the situation is even worse in the strange and charmed baryon sector. The experiments with antiproton-proton annihilation and proton-proton collisions are well suited for a comprehensive spectroscopy program, in particular, the spectroscopy of charmonuim-like states and flavour baryons. Charmed and strange baryons can be produced abundantly in both processes, and their properties can be studied in detail [1, 2, 3]. For this purpose an elaborated analysis of charmonium, charmed hybrid and tetraquark spectrum together with spectrum of charmed and strange baryons is given. The recent experimental data from different collaborations are analyzed. A special attention was given to the recently discovered XYZ-particles. The attempts of their possible interpretation are considered [4 - 7]. The results of physics simulation are obtained. Some of these states can be interpreted as higher-lying charmonium and tetraquarks with a hidden charm. It has been shown that charge/neutral tetraquarks must have their neutral/charged partners with mass values which differ by few MeV. This hypothesis coincides with that proposed by Maiani and Polosa [8]. Many heavy baryons with charm and strangeness are expected to exist. But much more data on different decay modes are needed before firmer conclusions can be made. These data can be derived directly from the experiments using a high quality antiproton beam with mo-mentum up to 15 GeV/c planned at FAIR and proton-proton collisions with momentum up to 20 GeV/c planned at the superconducting accelerator complex NICA.

[1] W. Erni et al., arXiv:0903.3905v1 [hep-ex] (2009) 63
[2] N. Brambilla et al., European Physical Journal C 71:1534, (2011) 1
[3] J. Beringer et al., Review of Particle Physic, Physical. Review, D 86, (2012)
[4] M.Yu. Barabanov, A.S. Vodopyanov, Physics of Particles and Nuclei Letters, V.8, N.10, (2011) 1069
[5] M.Yu. Barabanov, A.S. Vodopyanov, S.L. Olsen, Physics of Atomic Nuclei, V.77, N.1, (2014) 126
[6] M.Yu. Barabanov, A.S. Vodopyanov, S.L. Olsen , Physica Scripta, T 166 (2015) 014019
[7] M.Yu. Barabanov, A.S. Vodopyanov, S.L. Olsen, A.I. Zinchenko, Physics of Atomic Nuclei, V.79, N 1 (2016) 126
[8] L. Maiani, F. Piccinini, A.D. Polosa, V. Riquer, Phys. Rev. Lett. 99 (2007) 182003

Poster Session /

Study of the influence of the lowest tensor and scalar resonances on the $\tau \to \pi\pi\pi\nu_\tau$ width

Author(s): SHEKHOVTSOVA, Olga[1]
Co-author(s): PRZEDZINSKI, Tomasz[2] ; SANZ-CILLERO, Juan Jose[3]

[1]IFJ PAN

[2]Jagiellonian University

[3]Madrid University

Corresponding Author(s): olga.shekhovtsova@ifj.edu.pl

In this talk we present a new parametrization of the hadronic current for the decay $\tau \to \pi\pi\pi\nu_\tau$ derived from the chiral lagrangian with explicit inclusion of resonances. We have included both scalar, vector and axial-vector resonances as well, for the first time, the lowest tensor resonance (f2(1270)). Both single and double-resonance contributions to the hadronic form factors are taken into account. To satisfy the correct high energy behaviour of the hadronic form factors, constraints on numerical values of the vertex constants have been obtained. Also it has been emonstrated that the hadronic current reproduces its chiral limit. To get the model parameters we have fitted the one-dimensional pion invariant mass distributions to the preliminary BaBar data. Results of the fit are presented.

Poster Session /

Search for the C-violating meson decay $\eta \to \pi^0 e^+ e^-$ with WASA-at-COSY

DEMMICH, Kay[1]

[1]Westfälische Wilhelms-Universität Münster

for the WASA-at-COSY Collaboration

Corresponding Author(s): kay.demmich@uni-muenster.de

The C-symmetry as well as the invariance of the electromagnetic and the strong interaction under a charge conjugation transformation are basic concepts of the standard model. The electromagnetic decay $\eta \to \pi^0 e^+ e^-$ via a virtual photon violates the C-parity and alternative C-conserving processes are strongly suppressed. Hence, the η-meson is a perfect probe to test the conservation of the C-parity whithin the standard model and gives rise to search for physics beyond the standard model, e.g., dark bosons. Since this decay has not yet been observed, only an upper limit of the branching ratio of 4×10^{-5} is quoted by the PDG. A huge data set of $\approx 5 \times 10^8$ η mesons dedicated for studies on rare and forbidden η-decays has been recorded with the WASA-at-COSY setup, which allows for a determination of the relative branching ratio more sensitively than the recent upper limit. % The current status of the analysis will be presented.

Plenary Session /

The investigation of $K^+\pi^-$, π^+K^- and $\pi^+\pi^-$ atoms

YAZKOV, Valeriy[1]

[1]Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University

for the DIRAC Collaboration

Corresponding Author(s): valeri.yazkov@cern.ch

Theory, using Low Energy QCD, predicts with high precision the pion-pion and pion-kaon scattering lengths. There is accurate relation between $\pi^+\pi^-$ atom lifetime and a difference of S-wave pion-pion scattering lengths with isospin 0 (a_0) and 2 (a_2). Similar relation exists for $K^+\pi^-$ and π^+K^- atoms lifetime and pion-kaon scattering lengths with isospin 1/2 ($a_{1/2}$) and 3/2 ($a_{3/2}$). Experiment DIRAC at CERN PS detects 345 ± 61 pairs from $K^+\pi^-$ and π^+K^- atoms breakup. It allows to achieve the first observation of exotic atoms consisted of pion and kaon. Measured values of πK atom lifetime and corresponding pion-kaon scattering length difference are presented. It is shown, that experimental accuracy for pion-kaon scattering length difference could be significantly improved with an experiment at SPS energy.
The experimental observation of the long-lived $\pi^+\pi^-$ atoms is shown. The scheme to use the obtained data for the long-lived atom lifetime measurement will be described. Possibility of the long-lived $\pi^+\pi^-$ atom Lamb shift measurement and evaluation of pion-pion scattering length new combination ($|2 \cdot a_0 + a_2|$) is discussed.

Plenary Session /

Investigation of the low-energy kaons hadronic interactions in light nuclei by AMADEUS

SCORDO, Alessandro[1]

[1]Laboratori Nazionali di Frascati INFN

for the AMADEUS Collaboration

Corresponding Author(s): alessandro.scordo@lnf.infn.it

The AMADEUS experiment deals with the investigation of the low-energy kaon-nuclei hadronic interaction at the DAΦNE collider at LNF-INFN, which is fundamental to solve longstanding questions in the non-perturbative strangeness QCD sector. AMADEUS step 0 consisted in the reanalysis of 2004/2005 KLOE data, exploiting K^- absorptions in H, ^{4}He, ^{9}Be and ^{12}C, leading to the first invariant mass spectroscopy study with very low momentum (100MeV) in-flight K^- captures. With AMADEUS step 1 a dedicated pure Carbon target was implemented in the central region of the KLOE detector, providing a high statistic sample of pure at-rest K^- nuclear interaction.
The results obtained in the analyses of the hyperon-pion correlated events, searching for the resonant shapes of Y* states, and the analyses of hyperon-proton, deuteron, and triton correlations, searching for possible K^--multi nucleon bound states, will be presented.

Plenary Session /

Precision spectroscopy of pionic atoms and chiral symmetry in nuclei

ITAHASHI, Kenta[1]

[1]RIKEN

for the piAF Collaboration

Corresponding Author(s): itahashi@riken.jp

Precision spectroscopy of deeply bound pionic atoms with relatively heavy nuclei is known to provide information on the partial restoration of the chiral symmetry in nuclear medium. We have conducted a series of experimental spectroscopy of pionic atoms with unprecedented precision by using (d,^{3}He) reactions on tin isotopes. Recent analysis results are reported in the presentation.

Plenary Session /

Light kaonic atoms

OKADA, Shinji[1] ; TATSUNO, Hideyuki[2]

[1]RIKEN

[2]Lund University

Corresponding Author(s): hideyuki.tatsuno@gmail.com

A kaonic atom is a Coulomb-bound system formed by a kaon, electrons, and a nucleus. Effects of the strong interaction between the kaon and atomic nucleus are experimentally extracted from characteristic x-ray-emission spectra of the most tightly bound energy levels that are the most perturbed by the strong force. Especially on the light kaonic atom studies, there are significant progress in resent years and the further experiments are scheduled in J-PARC (Japan) and DAFNE (Italy). In this talk, an overview of those experimental studies and the future plans will be given.

As for the simplest kaonic atom, so-called Kaonic hydrogen, the SIDDHARTA collaboration have recently measured the K-series x-rays with significant improvements over the previous experiments [1]. This measurement offers a unique possibility to determine the KN s-wave scattering lengths, which is one of the most important observable to investigate chiral SU(3) dynamics in low-energy QCD. It is also strongly related to recent hot topics of the structure of the $\Lambda(1405)$ resonance and possible deeply bound kaonic systems. For further understanding of the KN interaction, especially to disentangle the isoscalar and isovector scattering lengths, a challenging measurement of the kaonic-deuterium K-series x-rays is planed at DAFNE (SIDDHARTA2) [2] and at J-PARC hadron facility (J-PARC E57) [3].

On the other hand, the depth of K-nucleus potential remains still unknown because of insufficient precision of kaonic-atom data for more than $Z \geq 2$, despite of significant progress of kaonic hydrogen ($Z = 1$). This is tied closely to the puzzling situation on experimental and theoretical studies of kaonic nuclei, and is one of the greatest concerns in the recent strangeness nuclear physics [4]. Aiming to provide a breakthrough, we will perform high-resolution x-ray spectroscopy of kaonic atoms at a J-PARC hadron beamline using a novel cryogenic detector, namely superconducting transition-edge-sensor (TES) microcalorimeter, which has unprecedented high energy resolution [5-7]. Very recently, a pathfinding experiment by measuring pionic-atom x-rays was performed

with a 240-pixel TES array at PSI, and the feasibility of TES-based exotic-atom x-ray spectroscopy in a hadron-beam environment was successfully demonstrated [8]. Based on the results, an ultra-high resolution x-ray spectroscopy of kaonic helium is prepared (J-PARC E62) [9]. Additionally, hadronic-atom x-ray spectroscopy has been used as a tool for measuring the charged hadron mass; we intend to improve the precision of the charged kaon mass measurement with TES spectrometers as well. This talk will also cover the new kaonic-atom project with the novel technology.
[1] SIDDHARTA collaboration, Phys. Lett. B 704 (2011) 113-117.
[2] SIDDHARTA-2 Collaboration, Proposal of Laboratori Nazionali di Frascati of INFN, The upgrade of the SIDDHARTA apparatus for an enriched scientific case, 2010.
[3] J. Zmeskal et al., Proposal for J-PARC 30-GeV Proton Synchrotron, Measurement of the strong interaction induced shift and width of the 1st state of kaonic deuterium at J-PARC (J-PARC E62), 2014.
[4] A. Gal, Nucl. Phys. A 914 (2013) 270-279.
[5] C. Ends (ed.), Cryogenic Particle Detection, Topics in Applied Physics, vol. 99, Springer, 2005.
[6] J.N. Ullom et al., Appl. Phys. Lett. 87 (2005) 194103.
[7] D.A. Bennett et al., Rev. Sci. Instrum. 83 (2012) 093113.
[8] H. Tatasuno et al., J. Low. Temp. Phys., DOI 10.1007/s10909-016-1491-2 (2016).
[9] R.S. Hayano, et al., Proposal for J-PARC 30-GeV Proton Synchrotron, Precision spectroscopy of kaonic atom X-rays with TES (J-PARC E62), 2015.

Plenary Session /

Kaon experiments at CERN: recent results and prospects

GOUDZOVSKI, Evgueni[1]

[1]University of Birmingham

for the NA48/2 and NA62 Collaboration

Corresponding Author(s): eg@hep.ph.bham.ac.uk

CERN has hosted a sequence of dedicated high intensity kaon physics experiments over several decades. The most recent of these experiments are NA48/2 (collected data in 2003-2004), NA62-RK (collected data in 2007) and NA62 (on-going, first physics data collected in 2015). Recent new results from these experiment are presented, including a search for lepton number violation in kaon decays, searches for exotic particles (heavy neutral leptons, dark photon, inflaton) in changed kaon and neutral pion decays, and measurement of the form factor of the neutral pion. The status and prospects of the on-going NA62 experiment and the quality of the data collected recently are also discussed.

Plenary Session /

The KLOE-2 experiment at DAFNE

SILARSKI, Michał[1]

[1]LNF INFN Frascati

for the KLOE-2 Collaboration

Corresponding Author(s): michal.silarski@lnf.infn.it

The KLOE-2 experiment at the INFN Laboratori Nazionali di Frascati (LNF) is currently taking data at the upgraded e^+e^- DAFNE collider. Present Run II follows a development phase to assess the feasibility of a long term acquisition program, Run I, which successfully ended in July 2015 with 1 fb^{-1} integrated luminosity collected in less than eight months. For the first time the "crab-waist" concept – an interaction scheme, developed in Frascati, where the transverse dimensions of the beams and their crossing angle are tuned to maximize the machine luminosity – has been applied in presence of a high-field detector solenoid. Record performance in terms of 2 x 10^{32} $cm^{-2}s^{-1}$ peak luminosity and 12 pb^{-1} maximum daily integrated luminosity were achieved with this innovative scheme of beam collisions, which will be employed in the upgrade of the B-factory currently under construction at the KEK Laboratory, in Japan, and is also considered a valid option in several future projects.
KLOE-2 represents the continuation of KLOE with a new physics program mainly focused on the study of K_s, η and η' decays as well as on kaon interferometry, test of discrete symmetries, and search for physics beyond the Standard Model. The new data taking campaign aiming to collect more than 5 fb^{-1} integrated luminosity in the next 2-3 years, will allow to perform CPT symmetry and quantum coherence tests using entangled neutral kaons with an unprecedented precision, high precision studies of $\gamma\gamma$-physics processes like $e^+e^- \to e^+e^-\pi^0(\gamma\gamma \to \pi^0)$, and the search for signals of a hidden dark-matter sector, among the fields to be addressed. The general purpose KLOE detector, composed by one of the biggest Drift Chamber ever built surrounded by a lead-scintillating fiber Electromagnetic Calorimeter among the best ones for energy and timing performance at low energies, undergone several upgrades including State-of-The-art cylindrical GEM detector: the Inner Tracker. To improve its vertex reconstruction capabilities near the interaction region, KLOE-2 is the first high-energy experiment using the GEM technology with a cylindrical geometry, a novel idea that was developed at LNF exploiting the kapton properties to build a transparent and compact tracking system. To study $\gamma\gamma$-physics the detector has been upgraded with two pairs of electron-positron taggers: the Low Energy Tagger (LET), inside the KLOE apparatus, and the High Energy Tagger (HET) along the beam lines outside the KLOE detector. An overview of the KLOE-2 experiment will be given including present status and achievements together with physics plans.

Plenary Session /

Building nucleons and nuclei from quarks and glue: highlights of nuclear physics research at Jefferson Lab in the "6 GeV era"

CARDMAN, Lawrence[1]

[1]Thomas Jefferson National Accelerator Facility

Corresponding Author(s): cardman@jlab.org

The intense, cw beams of polarized electrons with energies of up to 6 GeV from the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab have provided a unique tool for the study of atomic nuclei and their constituents. One hundred and seventy three experiments were carried out using the original accelerator configuration between 1995, when operations began, and 2012, when the facility ceased operation to start the 12 GeV Upgrade now nearing completion. These experiments advanced a broad range of nuclear physics research aimed at addressing key questions in the field, such as: how nucleons are constructed from the quarks and gluons of QCD; how the strong force arises from the underlying QCD quark-quark interaction; and where the conventional description of nuclei based on nucleons interacting via the nuclear force breaks down. Another major line of research emerged aimed at testing the Standard Model through very high precision experiments at low energies. The broad outlines of this research will be reviewed, and highlights from the program will be presented.

Plenary Session /

Production and decay of baryonic resonances in pion induced reactions

PRZYGODA, Witold[1]

[1]Jagiellonian University

for the HADES Collaboration

Corresponding Author(s): witold.przygoda@uj.edu.pl

An overview of experimental world database as well as theoretical models (in particular partial wave analysis) will be given. An example of the unique data gathered by HADES experiment both in hadron and dilepton channel will be presented. (t.b.c.)

Parallel Session A5 /

Photoproduction of vector mesons: from ultraperipheral to semi-central heavy ion collisions

Author(s): KŁUSEK-GAWENDA, Mariola[1]
Co-author(s): SZCZUREK, Antoni[2]

[1]Institute of Nuclear Physics PAN,

[2]Institute of Nuclear Physics PAN, Krakow and Rzeszow University, Rzeszow

Corresponding Author(s): mariola.klusek@ifj.edu.pl

We shall present nuclear cross section for $AA \to AAV$ and $AA \to AAVV$ processes where A means a nucleus (lead or gold) and V denotes ρ^0 or J/ψ vector meson. Analysis is done in the impact parameter space equivalent photon approximation. This approach allows to consider a particular process taking into account distance between colliding nuclei. We consider both ultraperipheral and for the first time semi-central collisions.
We get very good description of the latest ALICE data [1] for single J/ψ photoproduction for different centrality bins. We are first group which undertook a study of this process. We show that a correct interpretation of data needs to use a modification of a photon flux. Finally, we obtained reasonable results but we will try to discuss ''open questions".
Next, total and differential cross section for double-scattering mechanism in the exclusive $AA \to AAVV$ reaction in ultrarelativistic ultraperipheral heavy ion collisions will be presented. In this context we shall consider double photoproduction and photon-photon processes. Simultaneously, we will present very good agreement of our results with STAR [2] (RHIC), CMS [3] and ALICE [4,5] (LHC) experimental data for single ρ^0 and J/ψ vector meson production. The cross section for $\gamma A \to VA$ is parametrized based on an existing model. Our analysis includes a smearing of ρ^0 mass using a parametrization of the ALICE Collaboration.
We will show importance of $\rho^0(770)$ and $\rho^0(1450)$ decay into $\pi^+\pi^-$ channel. Additionally, we shall present a comparison of our predictions for exclusive four charged pions production.
In our calculations we use so-called realistic form factor which is a Fourier transform of the charge distribution in nuclei. This talk will be based mainly on analyses which were studied in Ref. [6] and [7].
References:
[1] ALICE Collaboration, J. Adam et al., arXiv: nucl-ex/1509.08802
[2] STAR Collaboration, B. I. Abelev et al., Phys. Rev. \textbf{C77} (2008) 034910
[3] CMS Collaboration, CMS-PAS-HIN-12-009 (2014)
[4] ALICE Collaboration, B. Abelev et al., Phys. Lett. B718 (2013) 1273
[5] ALICE Collaboration, E. Abbas et al., Eur. Phys. J. C73 (2013) 2617
[6] M. Kłusek-Gawenda and A. Szczurek, Phys. Rev. C89 (2014) 024912
[7] M. Kłusek-Gawenda and A. Szczurek, arXiv: nucl-th/1509.03173

Parallel Session A5 /

Locally gauge-invariant incorporation of Regge-trajectory exchanges into effective Lagrangian descriptions of photoproduction processes

HABERZETTL, Helmut[1]

[1]The George Washington University

Corresponding Author(s): helmut@gwu.edu

It is well known that in effective Lagrangian formulations of photon-induced meson-production processes simply replacing standard Feynman-type t-channel exchanges by exchanges of Regge trajectories violates gauge invariance. We point out that the usual procedure for remedying this defect is flawed, and we show how to construct a contact current whose four-divergence cancels the gauge-invariance-violating contributions resulting from all states above the base state on the Regge trajectory. By construction, the corresponding complete production current satisfies the appropriate (off-shell) generalized Ward-Takahashi identity and thus preserves full local gauge invariance as a matter of course. An application to recent Jefferson Lab data for the process $\gamma + n \to K^+ + \Sigma^*(1385)^-$ at photon energies between 1.5 and 2.5 GeV is discussed as well.

Parallel Session A5 /

Photoproduction of tensor mesons

Author(s): XIE, Ju-Jun[1]
Co-author(s): OSET, Eulogio[2] ; GENG, Li-Sheng[3]

[1]Institute of Modern Physics, CAS

[2]IFIC, Valencia, Spain

[3]Beihang University, Beijing, China

Corresponding Author(s): xiejujun@impcas.ac.cn

Assuming that the $f_2(1270)$, $f_2(1525)$, $a_2(1320)$, and $K_2^\star(1430)$ resonances are dynamically generated states from vector-meson–vector-meson interactions in the s-wave with spin $S = 2$, we study the $\gamma p \to f_2(1270)p$, $f_2(1525)p$, $a_2^0(1320)p$, and $\gamma p \to K_2^\star(1430)\Lambda(\Sigma)$ reactions. These reactions proceed in the following way: the incoming photon first mutates into a ρ^0, ω, or ϕ meson via vector-meson dominance, which then interacts with the ρ^0, ω, or $K^\star$ emitted by the incoming proton to form the tensor mesons $f_2(1270)$, $f_2(1525)$, $a_2(1320)$, and $K_2^\star(1430)$. The picture is simple and has no free parameters, as all the parameters of the mechanism have been fixed in previous studies. We predict the differential and total cross sections of these reactions. The results can be tested in future experiments and therefore offer new clues about the nature of these tensor states.

Parallel Session A5 /

Photoproduction of η and $\eta\prime$ with EtaMAID

Author(s): TIATOR, Lothar[1]
Co-author(s): OSTRICK, Michael[1] ; KASHEVAROV, Viktor[1]

[1]Institut für Kernphysik, Universität Mainz

Corresponding Author(s): tiator@kph.uni-mainz.de

The isobar model EtaMAID is an online program of the MAID collaboration in Mainz for calculations of observables, amplitudes and multipoles for η and $\eta\prime$ photo- and electroproduction on the nucleon. It was introduced in 2001 and updated in 2003. Now we will present a new update EtaMAID2016, taking into account very recent high-precision data of differential cross sections for $p(\gamma,\eta)p$ and $p(\gamma,\eta\prime)p$ from MAMI and polarization observables with beam and target polarization from MAMI, ELSA, JLab and GRAAL. The high-energy region $W > 2$ GeV is set-up with Regge trajectories and Regge cuts and can well describe all high-energy data including polarization observables for γ,π^0, γ,η and $\gamma,\eta\prime$. In the resonance region below $W \approx 2$ GeV we investigated more than 20 N^* resonances and found significant contributions for 18 of them. A very good description has been obtained for all existing photoproduction data.

Parallel Session B5 /

Charge symmetry breaking in light hypernuclei

ACHENBACH, Patrick[1]

[1]Mainz University

for the A1 Collaboration

Corresponding Author(s): achenbach@uni-mainz.de

At the Mainz Microtron MAMI the high-resolution spectroscopy of decay-pions in strangeness electro-production is used to extract the Λ hyperon ground state binding energy in ${}^{4}_{\Lambda}$H. This binding energy is used together with the ${}^{4}_{\Lambda}$He ground state binding energy from nuclear emulsion experiments and with energy levels of the 1^+ excited state for both hypernuclei from γ-ray spectroscopy to address the charge symmetry in the strong interaction. The full understanding of the large and spin-dependent breaking of this symmetry in the $A = 4$ hypernuclei still remains one of the open issues of hypernuclear physics.

Parallel Session B5 /

Mixing and CP-violation in the B_d and B_s systems at ATLAS

WHARTON, Andy[1]

[1]Lancaster University

for the ATLAS Collaboration

Corresponding Author(s): andy.wharton@cern.ch

Search for deviations from the standard model is performed in the systems of the neutral B mesons. The Bs system is studied in the decay into J/psi phi. The mixing phase phi_s and the width difference DeltaGamma_s are determined through the simultaneous study of angular distributions in the final state and of the decay time, performed together with flavour tagging at production. The measurement performed by ATLAS with the full LHC Run-1 sample is discussed and compared to the previous world average. The width difference DeltaGamma_d in the Bd system is obtained from the comparison of the decay time distributions in the flavour specific state J/psi K* and in the CP eigenstate J/psi KS. The result obtained from the full sample of data collected by ATLAS at 7 and 8 TeV is the most accurate single measurement of the width difference currently available.

Parallel Session B5 /

Studies of discrete symmetries in a purely leptonic system

MOSKAL, Paweł[1]

[1]Jagiellonian University

for the J-PET Collaboration

Corresponding Author(s): p.moskal@uj.edu.pl

The C, CP, T and CPT symmetries are of fundamental importance in physics. Violation of T or CP invariance in purely leptonic systems have never been seen so far. Based on known mechanisms of C and CP violations, one cannot explain the large asymmetry between matter and antimatter in the observable Universe. Positronium is the lightest purely leptonic object decaying into photons. As an atom bound by a central potential, it is a parity eigenstate, and as an atom built out of an electron and an anti-electron, it is an eigenstate of the charge conjugation operator. Therefore, the positronium is a unique laboratory to study discrete symmetries whose precision is limited, in principle, by the effects due to the weak interactions expected at the level of 10^{-14} and photon–photon interactions expected at the level of 10^{-9}. The newly constructed J-PET detector enables to perform tests of discrete symmetries in the leptonic sector via the determination of the expectation values of the discrete-symmetries-odd operators, which may be constructed from the spin of ortho-positronium atom and the momenta and polarization vectors of photons originating from its annihilation. We will present the potential of the J-PET detector to test the C, CP, T and CPT symmetries in the decays of positronium atoms. With respect to the previous experiments performed with crystal based detectors, J-PET built of plastic scintillators, provides superior time resolution, higher granularity, lower pile-ups, and opportunity of determining photon's polarization. These features allow us to expect a significant improvement in tests of discrete symmetries in decays of positronium atom (a purely leptonic system).
J-PET: P. Moskal et al., Acta Phys.Polon. B47 (2016) 509.
J-PET: A. Gajos et al., Nucl. Instrum. Meth. A819 (2016) 54.
J-PET: D. Kamińska et al., Nukleonika 60 (2015) 729.
J-PET: P. Moskal et al., Nucl. Instrum. Meth. A775 (2015) 54.
J-PET: P. Moskal et al., Nucl. Instrum. Meth. A764 (2014) 317.
J-PET: P. Moskal, D. Alfs, T. Bednarski, P. Białas, E. Czerwiński, A. Gajos, B. Głowacz, D. Kamińska, A. Khreptak, G. Korcyl, T. Kozik, N. Krawczyk, E. Kubicz, M. Mohammed, Sz. Niedźwiecki, M. Pawlik-Niedźwiecka, Z. Rudy, M. Silarski, A. Wieczorek, M. Zieliński (Jagiellonian U., Cracow), C. Curceanu (LNF Frascati) M. Gorgol, B. Jasińska, B. Zgardzińska (Maria Curie U., Lublin), B.C. Hiesmayr (Vienna U.), P. Kowalski, W. Krzemień, L. Raczyński, W. Wiślicki, (NCBJ, Swierk)

Parallel Session B5 /

Search for $K^+ \to \pi^+\nu\nu$ at NA62

LAZZERONI, Cristina[1] ; DUK, Viacheslav[2]

[1]University of Birmingham

[2]INFN Perugia

for the NA62 Collaboration

Corresponding Author(s): viacheslav.duk@cern.ch

$K^+ \to \pi^+\nu\nu$ is one of the theoretically cleanest meson decay where to look for indirect effects of new physics complementary to LHC searches. The NA62 experiment at CERN SPS is designed to measure the branching ratio of this decay with 10% precision. NA62 took data in pilot runs in 2014 and 2015 reaching the final designed beam intensity. The quality of data acquired in view of the final measurement will be presented.

Parallel Session C5 /

Pion transition form factor to a highly off-shell and a quasi on-shell photon

Author(s): BASHIR, Adnan[1]
Co-author(s): CHANG, Lei[2] ; ROBERTS, Craig D.[3] ; RAYA, Khépani[1]

[1]Universidad Michoacana

[2]Nankai University

[3]Argonne National Laboratory

Corresponding Author(s): adnan@ifm.umich.mx

Experimental efforts like the ones in Babar and Belle Experiments have contributed importantly in the last few years towards our improved understanding of the pion transition form factor to two photons. The modern challenge is to start from QCD's fundamental degrees of freedom, namely quarks and gluons, and map out quantitative predictions for this form factor in a unified picture which ranges from non-perturbative to the asymptotic domain of the theory. In continuum, systematically improvable modeling of the Schwinger-Dyson equations holds the promise to undertake this challenge. I present the recent results obtained within this approach.

Parallel Session C5 /

Construction of the pion scalar form factor from few poles and zero

Author(s): KAMIŃSKI, Robert[1]
Co-author(s): DUBNICKA, Stanislav[2] ; DUBNICKOVA, Anna Zuzana[3] ; LIPTAJ, Andrej[4]

[1]Institute of Nuclear Physics PAN, Kraków

[2]Inst of Physics SAS

[3]Comenius University

[4]Institute of Physics, Slovak Academy of Sciences, Dubravska cesta 9, 845 11 Bratislava 45, Slovak Republic

Corresponding Author(s): robert.kaminski@ifj.edu.pl

Very simple and self-sufficient method of construction and definitive-full analysis of the pion scalar-isoscalar form factor in the elastic region is presented. It is based on precise S-wave $\pi\pi$ scattering phase shifts generated by dispersive analysis of experimental data with imposed crossing symmetry condition. Final result for values of the $f_0(500)$ meson mass and width, $m_\sigma = (459 \pm 22)$ MeV; $\Gamma_\sigma = (521 \pm 60)$ MeV is compatible with the results from dispersive analyses of the BERN and MADRID groups to be considered now as the most reliable values of the $f_0(500)$ scalar meson parameters, though in presented analysis another, unusual way has been applied. Self-sufficiency of the proposed derivation of the constructed form factor and its predictions near the $K\bar{K}$ threshold have been examined.

Parallel Session C5 /

Threshold π^- photoproduction

Author(s): STRANDBERG, Bruno[1]
Co-author(s): FELDMAN, Gerald[2] ; FISSUM, Kevin[3] ; MYERS, Luke[4] ; O'RIELLY, Grant V.[5] ; ANNAND, John R.M.[1] ; BRISCOE, William[2]

[1]The University Of Glasgow

[2]The George Washington University

[3]Lund University

[4]Bluffton University

[5]University of Massachusetts Dartmouth

for the MAX-Tagg Collaboration

Corresponding Author(s): b.strandberg.1@research.gla.ac.uk

The last Nuclear Physics experiment at Maxlab in Lund, Sweden was performed in April 2015. The experiment probes the π^- photoproduction on the neutron through measuring the total cross-section of the reaction $\gamma + {}^2\mathrm{H} \rightarrow ß^- + 2\mathrm{p}$ from threshold up to ~ 165 MeV incident photon energy.
Pion photoproduction on the nucleus is described by various theoretical frameworks (e.g Dispersion Theory, Heavy Baryon Chiral Perturbation Theory) and experimental data is vital to test the accuracy of the models. Numerous experiments have been performed to study the π^0 channel, but data on the charged channels is scarce. To the best of the authors knowledge no data exists for π^- photoproduction below incident photon energy of 158 MeV.
The presentation will provide an overview of the $\gamma + {}^2\mathrm{H} \rightarrow ß^- + 2\mathrm{p}$ experiment performed at Maxlab in Lund, Sweden. The author will explain the key aspects of the analysis, present the latest results and outline the data points that should become available within the next year. In addition to the π^- production channel the Compton scattering data $\gamma + {}^2\mathrm{H} \rightarrow \mathrm{fl}' + {}^2\mathrm{H}'$ that can be extracted from the same experiment will be briefly discussed.

Parallel Session C5 /

Production and interaction of the η meson with nucleons and nuclei

KRZEMIEŃ, Wojciech[1]

[1]National Centre for Nuclear Research

for the WASA-at-COSY Collaboration

Corresponding Author(s): wojciech.krzemien@ncbj.gov.pl

We will report on the status of the search for η-mesic nuclei and the studies of the interaction of the η meson with nucleons. Recently we have completed the analysis of the new WASA-at-COSY data on the production of the η meson with polarized proton beam. New results on the analyzing power for the $pp \rightarrow pp\eta$ reaction with more than an order of magnitude improved precision shed a new light on the $p - \eta$ interaction as well as on the production mechanism of the η meson in nucleon-nucleon collisions. Also, the latest results of the search for η-mesic nuclei will be discussed.

Parallel Session A6 /

The $\Lambda_b \to J/\psi K^- p$ and related reactions showing signals for hidden charm states with and without strangeness

OSET, Eulogio[1]

[1]University of Valencia

Corresponding Author(s): oset@ific.uv.es

I shall report on recent developments of different reactions: $\Lambda_b \to J/\psi K^- p$, $\Lambda_b \to J/\psi \pi^- p$, $\Lambda_b \to J/\psi \eta \Lambda$, $\Lambda_b \to J/\psi K \Lambda$ and $\Xi_b \to J/\psi K \Lambda$, showing that the LHCb results for the first two reactions are consistent with previous predictions of hidden charm molecular states, and then making predictions for the observation with the other reactions of hidden states with strangeness, also predicted before. The content of the presentation is based on the papers [1-6].

[1] L. Roca, J. Nieves and E. Oset, Phys. Rev. D 92, 094003 (2015)
[2] L. Roca and E. Oset, arXiv:1602.06791 [hep-ph]
[3] J. X. Lu, E. Wang, J. J. Xie, L. S. Geng and E. Oset, arXiv:1601.00075 [hep-ph]
[4] E. Wang, H. X. Chen, L. S. Geng, D. M. Li and E. Oset, arXiv:1512.01959 [hep-ph]
[5] H. X. Chen, L. S. Geng, W. H. Liang, E. Oset, E. Wang and J. J. Xie, arXiv:1510.01803 [hep-ph]
[6] A. Feijoo, V. K. Magas, A. Ramos and E. Oset, arXiv:1512.08152 [hep-ph]

Parallel Session A6 /

Charmed meson scattering from lattice QCD

MOIR, Graham[1]

[1]University of Cambridge

Corresponding Author(s): moirg@tcd.ie

We present a lattice QCD determination of scattering amplitudes arising in coupled-channel $D\pi$, $D\eta$ and $D_s\bar{K}$ scattering along with those arising in single-channel DK scattering. We also present highly excited spectra of hidden and open-charm mesons and comment on states with exotic quantum numbers and those with apparent gluonic degrees of freedom.

Parallel Session A6 /

Double open charm meson production at the LHC: New single- and double-parton scattering mechanisms

MACIUŁA, Rafał[1]

[1]Institute of Nuclear Physics PAN

Corresponding Author(s): rafal.maciula@ifj.edu.pl

Some time ago two of us predicted that at large energies relevant for the LHC the production of double charm should be dominated by the double-parton scattering (DPS) mechanism [1]. Those studies of double $\bar{c}c$ production was extended next to the k_t-factorization approach which includes effectively higher-order QCD effects [2, 3]. A relatively good description of the LHCb experimental data [4] was achieved for both the total yield and the dimeson correlation observables. The single-parton scattering (SPS) $gg \to c\bar{c}c\bar{c}$ contribution was discussed carefully in both collinear [3] and k_t-factorization

[5] approaches. Their contribution to the $c\bar{c}c\bar{c}$ cross section was found to be rather small and was not able to describe details of the LHCb data.
Here we discuss production of D^0D^0 (and $\bar{D^0}\bar{D^0}$) pairs within an alternative approach where g $\to$ D fragmentation is included [6]. We consider double-parton scattering (DPS) mechanisms of double $c\bar{c}$ production and subsequent $cc \to D^0D^0$ hadronization as well as double g and mixed $gc\bar{c}$ production with $gg \to D^0D^0$ and $gc \to D^0D^0$ hadronization calculated with the help of the scale-dependent hadronization functions of Kniehl et al. Single-parton scattering (SPS) mechanism of digluon production is also taken into account. We compare our results with several correlation observables in azimuthal angle $\phi_{D^0D^0}$ between D^0 mesons or in dimeson invariant mass $M_{D^0D^0}$. The inclusion of new mechanisms with $g \to D^0$ fragmentation leads to larger cross sections, than when including only DPS mechanism with standard scale-independent $cc \to D^0D^0$ fragmentation functions. Some consequences of the presence of the new mechanisms are discussed. In particular a larger σ_{eff} is needed to describe the LHCb data. There is a signature that σ_{eff} may depend on transverse momentum of c quarks and/or $\bar{c}$ antiquarks.
[1] M. Luszczak, R. Maciula and A. Szczurek, Phys. Rev. D 85, 094034 (2012).
[2] R. Maciula and A. Szczurek, Phys. Rev. D 87, 074039 (2013).
[3] A. van Hameren, R. Maciula and A. Szczurek, Phys. Rev. D 89, 094019 (2014).
[4] R. Aaij et al. [LHCb Collaboration], J. High Energy Phys. 06, 141 (2012); [J. High Energy Phys. 03, 108 (2014)].
[5] A. van Hameren, R. Maciula and A. Szczurek, Phys. Lett. B 748, 167 (2015).
[6] R. Maciula and V. A. Saleev, A. V. Shipilova and A. Szczurek, arXiv:1601.06981 [hep-ph]

Parallel Session A6 /

The interference effects of multi-channel pion-pion scattering contributions to the final states of Ψ- and ϒ-meson family decays

Author(s): SUROVTSEV, Yury[1]
Co-author(s): KAMIŃSKI, Robert[2] ; BYDZOVSKY, Petr[3] ; GUTSCHE, Thomas[4] ; LYUBOVITSKIJ, Valeri[4] ; NAGY, Miroslav[5]

[1]Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research

[2]Institute of Nuclear Physics PAN, Kraków

[3]Nuclear Physics Institute, CAS Rez

[4]Universitaet Tuebingen

[5]Institute of Physics, SAS

Corresponding Author(s): surovcev@theor.jinr.ru

There is presented a unified analysis of all available data on the decays of bottomonia $\Upsilon(mS) \to \Upsilon(nS)\pi\pi$ ($m > n$, $m = 2, 3, 4, 5$, $n = 1, 2, 3$), charmonia $J/\psi \to \phi(\pi\pi, K\overline{K})$, $\psi(2S) \to J/\psi\pi\pi$ and the data on isoscalar S-wave processes $\pi\pi \to \pi\pi, K\overline{K}, \eta\eta$. The multi-channel $\pi\pi$ scattering is described in our model-independent approach based on analyticity and unitarity and using an uniformization procedure. It is shown that the basic shape of dipion mass distributions in the two-pion transitions of both charmonia and bottomonia states are explained by an unified mechanism based on the contribution of the $\pi\pi$, $K\overline{K}$ and $\eta\eta$ coupled channels including their interference. The role of the individual f_0 resonances in contributing to the dipion mass distributions in indicated decays of these states is considered. Since the satisfactory description of these decays with allowing for the $\eta\eta$ channel (in addition to the $\pi\pi$ and $K\overline{K}$ one) did not require

any change of the f_0-meson parameters, the results of the analysis confirm convincingly all of our earlier conclusions on the scalar mesons.

[1] Yu.S. Surovtsev et al., J. Phys. G: Nucl. Part. Phys. 41 (2014) 025006.
[2] Yu.S. Surovtsev et al., Phys. Rev. D 89 (2014) 036010.
[3] Yu.S. Surovtsev et al., Phys. Rev. D 91 (2015) 037901.
[4] Yu.S. Surovtsev et al., Phys. Rev. D 92 (2015) 036002.

Parallel Session B6 /

Photoproduction of J/ψ and Υ in exclusive and proton-dissociative diffractive events

Author(s): SCHAEFER, Wolfgang[1]
Co-author(s): CISEK, Anna[2] ; SZCZUREK, Antoni[3]

[1]IFJ PAN Krakow

[2]Univesrity of Rzeszow

[3]Institute of Nuclear Physics PAN, Krakow and Rzeszow University, Rzeszow

Corresponding Author(s): wolfgang.schafer@ifj.edu.pl

The amplitude for $\gamma p \to Vp$, where V is a J/ψ or Υ ground state or excited vector meson, is calculated in a pQCD k_T-factorization approach. We use this amplitude to predict the cross section for exclusive photoproduction of $J/\psi, psi', \Upsilon$ mesons in proton-proton collisions. Calculations are performed for a variety of unintegrated gluon distributions, and we compare to LHCb data. Compared to earlier calculations we include both Dirac and Pauli electromagnetic form factors. We discuss the role of the $Q\bar{Q}$ light-cone wave functions for differential distributions for ratios such as $\sigma(\psi')/\sigma(J/\psi)$. Absorption effects are taken into account and their role is discussed in detail.
We also discuss the related diffractive production in proton dissociative events. Here special emphasis is put on electromagnetic dissociation , which is calculable without additional free parameters. Besides being of interest in their own right, they constitute an important experimental background to exclusive production. We also comment on the role of dissociative photoproduction for other states, e.g. light vector mesons.
The talk will be based on A. Cisek, W. Schafer and A. Szczurek, JHEP 1504 (2015) 159 and ongoing work by the same authors.

Parallel Session B6 /

Amplitude analysis of $J/\psi \to \gamma\pi^0\pi^0$

PILLONI, Alessandro[1]

[1]Thomas Jefferson National Accelerator Facility

Corresponding Author(s): pillaus@jlab.org

The radiative decays of the J/ψ are of great importance for the search and the identification of the scalar glueball. We discuss an amplitude analysis for the J/ψ radiative decay to $\pi^0\pi^0$, and apply the formalism to the data recently published by BESIII.

Parallel Session B6 /

Measurement of the cross-section ratio $\sigma(\psi(2S))/\sigma(J/\psi(1S))$ in exclusive deep inelastic ep scattering and in photoproduction at HERA

CIBOROWSKI, Jacek[1]

[1]University of Warsaw

for the ZEUS Collaboration

Corresponding Author(s): cib@fuw.edu.pl

The exclusive deep inelastic electroproduction of $\psi(2S)$ and $J/\psi(1S)$ at an ep centre-of-mass energy of 317 GeV have been studied with the ZEUS detector at HERA in the kinematic range $2 < Q^2 < 80$ GeV^2, $30 < W < 210$ GeV and $|t| < 1$ GeV^2, where Q^2 is the photon virtuality, W is the photon-proton centre-of-mass energy and t is the squared four-momentum transfer at the proton vertex. The data for $2 < Q^2 < 5$ GeV^2 were taken in the HERA I running period and correspond to an integrated luminosity of 114 pb^{-1}. The data for $5 < Q^2 < 80$ GeV^2 are from both HERA I and HERA II periods and correspond to an integrated luminosity of 468 pb^{-1}. Also, the exclusive photoproduction reaction $\gamma p \to \Psi(2S)p$ has been studied using an integrated luminosity of 350 pb^{-1}. The measurement has been performed in the kinematic range $30 < W < 180$ GeV, $Q^2 < 1$ GeV^2, $|t| < 5$ GeV^2. The decay modes analysed were $\mu^+\mu^-$ and $J/\psi(1S)\pi^+\pi^-$ for the $\psi(2S)$ and $\mu^+\mu^-$ for the $J/\psi(1S)$. The cross-section ratio $\sigma(\psi(2S))/\sigma(J/\psi(1S))$ has been measured as a function of Q^2, W, and t. The results are compared to predictions of QCD-inspired models of exclusive vector-meson production.

Parallel Session B6 /

Inclusive production of J/Ψ and Ψ' mesons at the LHC

Author(s): CISEK, Anna[1]
Co-author(s): SZCZUREK, Antoni[2]

[1]University of Rzeszow, PL-35-959 Rzeszow, Poland

[2]Institute of Nuclear Physics, PAN, PL-31-342 Krakow, Poland

Corresponding Author(s): acisek@ur.edu.pl

We discuss prompt production of J/ψ mesons in proton-proton collisions at the LHC within NRQCD k_t-factorization approach using Kimber-Martin-Ryskin (KMR) unintegrated gluon distributions (UGDF). We include both direct color-singlet production ($gg \to J/\psi g$) as well as a feed-down from $\chi_c \to J/\psi\gamma$ and $\psi' \to J/\psi X$. The production of the decaying mesons (χ_c or ψ') is also calculated within NRQCD k_t-factorization. The corresponding matrix elements for $gg \to J/\psi$, $gg \to \psi' g$ and $gg \to \chi_c$ include parameters of the nonrelativistic space wave functions of the quarkonia at $r = 0$, which are taken from potential models from the literature. We get the ratio of the corresponding cross sections for $\chi_c(2)$-to-$\chi_c(1)$ much closer to experimental data than obtained in a recent analysis. Differential distributions in rapidity and transverse momentum of J/ψ and ψ' are calculated and compared to experimental data of the ALICE and LHCb collaborations. We discuss a possible onset of gluon saturation effects at forward/backward rapidities. One can describe the experimental data for J/ψ production within model uncertainties with color-singlet component only. Therefore our theoretical results leave only a relatively small room for the color-octet contributions.

Parallel Session B6 /

Di-electron production in dp collisions at $E_{kin} = 2.5$ GeV

BIERNAT, Jacek[1]

[1]Jagiellonian University

for the HADES Collaboration

Corresponding Author(s): jacek.b.biernat@gmail.com

Investigation of di-electron pair production in quasi-free $n-p$ interactions using deuterium beams on proton target at kinetic energy of 1.25 GeV/u will be presented. Detection of

spectator proton from deuterium break-up at forward angles ($0.3^\circ < \theta < 7^\circ$) and electron-positron pairs and proton in High Acceptance Dielectron Spectromter (HADES) located at GSI allows for detailed analysis of the exclusive pair production in the $np \to npe^+e^-$ reaction. Obtained exclusive distributions will be compared to the corresponding one obtained from pp collisions at the same energy. The results will be compared with predictions obtained from available calculations. In particular interpretations of a striking difference in the pair production in both reactions will be discussed.

Parallel Session C6 /

K^+-nucleon amplitudes in the nuclear medium below 800 MeV/c

FRIEDMAN, Eliahu[1]

[1]Racah Institute of Physics, Hebrew University, Jerusalem

Corresponding Author(s): elifried@cc.huji.ac.il

Simple in-medium meson-nucleon kinematics has been applied recently in calculations of strong interaction effects in kaonic atoms [1-4], pionic atoms and elastic scattering of low energy pions by nuclei [4]. More sensitive tests of this approach are possible with K^+-nucleus interactions below 800 MeV/c because of the superior penetration of kaons into nuclei. Using this approach, calculated reaction and total cross sections for the very low density nucleus ^{6}Li agree with experiment to $\pm 3\%$ throughout the energy range. Calculations are $3\pm 4\%$ too low for C, Si and Ca, thus quantifying phenomenologically the enhancement in the nuclear medium observed before [6-8]. A brief discussion of this open problem is included [9].

[1] A. Cieply et al., Phys. Lett. B 702 (2011) 402
[2] A. Cieply et al., Phys. Rev. C 84 (2011)
[3] E. Friedman, A. Gal, Nucl. Phys. A 899 (2013) 60 and references therein
[4] A. Gal et al., EPJ Web of Conferences 81 (2014) 01018 and references therein
[5] E. Friedman, A. Gal, Nucl. Phys. A 928 (2014) 128
[6] D.V. Bugg et al., Phys. Rev. 168 (1968) 1466
[7] P.B. Siegel, W.B. Kaufmann, W.R. Gibbs, Phys. Rev. C 31 (1985) 2184
[8] R.J. Peterson, Phys. Rev. C 60 (1999) 022201 and references therein
[9] E. Friedman, Nucl. Phys. A (2016), in press

Parallel Session C6 /

Theoretical approaches to low energy $\bar{K}N$ interactions

CIEPLY, Ales[1]

[1]Nuclear Physics Institute

Corresponding Author(s): cieply@ujf.cas.cz

Several theoretical groups [1-4] describe the antikaon-nucleon interaction at low energies within approaches based on the chiral SU(3) dynamics and including next-to-leading order (NLO) contributions. We present a comparative analysis of the pertinent models and discuss in detail their pole contents. We note that the Kyoto-Munich [1] and Prague [2] models have relatively small NLO contributions (representing only moderate corrections to the LO chiral interactions) while the Murcia [3] and Bonn [4] models introduce sizable NLO terms that generate inter-channel couplings very different from those obtained by only the Weinberg-Tomozawa interaction.

The models reproduce the experimental data on a qualitatively very similar level and in mutual agreement especially concerning the data available at the $\bar{K}N$ threshold. They also tend to agree on a position of the higher energy of the two poles generated for the $\Lambda(1405)$ resonance. However, in our recent work [5] we demonstrated that the approaches lead to very different predictions for the K^-p amplitude extrapolated to subthreshold energies as well as for the K^-n amplitude. The theoretical ambiguities observed below the $\bar{K}N$ threshold are much larger then those indicated by uncertainty bounds derived from variations of the K^-p scattering length within constraints enforced by a recent SIDDHARTA measurement of the kaonic hydrogen characteristics [6].

We have also analysed the origin of the poles of the scattering T-matrix generated by the various theoretical models by following the pole movements to the so-called zero coupling limit, in which the inter-channel couplings are switched off. This procedure enabled us to reveal different concepts of forming the $\Lambda(1405)$ resonance and provided us with new insights related to the appearance of poles in a given approach. In particular, we discuss a possible isovector $\bar{K}N$ pole located below the $\bar{K}N$ threshold and demonstrate that an appearance of a pole in a given approach can be related to conditions imposed on the subtraction constants or inverse interaction ranges, the parameters fitted to reproduce the experimental data.

[1] Y.Ikeda, T.Hyodo and W.Weise, Nucl. Phys. A 881 (2012) 98
[2] A.Cieply and J.Smejkal, Nucl. Phys. A 881 (2012) 115
[3] Z.H.Guo and J.A.Oller, Phys. Rev. C 87 (2013) 035202
[4] M.Mai and U.-G.Meissner, Eur. Phys. J. A 51 (2015) 30
[5] A.Cieply, M.Mai, U.-G.Meissner and J.Smejkal, submitted to Nucl. Phys. A, arXiv:1603.02531 [hep-ph]
[6] M.Bazzi et al. [SIDDHARTA Collaboration], Phys. Lett. B 704 (2011) 113

Parallel Session C6 /

Calculations of kaonic nuclei based on chiral meson-baryon coupled channel interaction models

Author(s): HRTANKOVA, Jaroslava[1]
Co-author(s): CIEPLY, Ales[2] ; MARES, Jiri[2]

[1]Nuclear Physics Insitute, 250 68 Rez, Czech Republic

[2]Nuclear Physics Institute

Corresponding Author(s): hrtankova@ujf.cas.cz

We review our latest calculations of K^- nuclear quasi-bound states. We apply a self-consistent scheme for constructing K^--nuclear potentials V_K from subthreshold chirally inspired in-medium $\bar{K}N$ scattering amplitudes, which was introduced in Ref. [1,2]. We consider two in-medium versions of the scattering amplitudes: the version which takes into account only Pauli blocking in the intermediate states, and the version which adds self-consistently hadron self-energies. To explore the model dependence of our calculations, we constructed the underlying $\bar{K}N$ amplitudes within chirally motivated meson-baryon coupled-channel interaction models: Prague [3], Kyoto- Munich [4], Murcia [5], and Bonn [6]. They capture the physics of the $\Lambda(1405)$ and reproduce low energy $\bar{K}N$ observables, including the recent $1s$ level shift and width in the K^- hydrogen atom from the SIDDHARTA experiment [7].

Energy dependence of the in-medium scattering amplitudes, particularly in the K^-N subthreshold region, is the decisive mechanism that controls the self-consistent evaluation of corresponding K^- optical potentials. The role of hadron self-energies in the self-consistent calculations of the K^- binding energies B_K is less pronounced than the model dependence of predicted B_K.

The widths of low-lying K^- states due to $K^-N \to \pi Y$ conversions are substantially reduced in the self-consistent calculations, thus reflecting the proximity of the $\pi\Sigma$ threshold. On the contrary, the widths of higher excited K^- states are quite large even if only the pion conversion modes on a single nucleon are considered. After including 2 body $K^-NN \to YN$ absorption modes, the total decay widths Γ_K are comparable with the corresponding binding energies B_K for all K^- nuclear quasi-bound states, exceeding considerably the level spacing.

[1] A. Cieply, E. Friedman, A. Gal, D. Gazda, J. Mares, Phys. Lett. B 702 (2011) 402; Phys. Rev. C 84 (2011) 045206

[2] D. Gazda, J. Mares, Nucl. Phys. A 881 (2012) 159
[3] A. Cieply, J. Smejkal, Nucl. Phys. A 881 (2012) 115
[4] Y. Ikeda, T. Hyodo and W. Weise, Nucl. Phys. A 881 (2012) 98
[5] Z. H. Guo and J. A. Oller, Phys. Rev. C 87, no. 3,(2013) 035202
[6] M. Mai and U.-G. Meißner, Nucl. Phys. A 900, (2013) 51
[7] M. Bazzi et al (SIDDHARTA Collaboration), Phys. Lett. B 704 (2011) 113

Parallel Session C6 /

Near-threshold charged kaon pair production in two protons collisions

Author(s): GIL, Damian[1]
Co-author(s): SMYRSKI, Jerzy[1]

[1]Jagiellonian University

for the COSY-11 Collaboration

Corresponding Author(s): damian.gil@uj.edu.pl

The value of the total cross section of the $pp \to ppK^+K^-$ reaction close to threshold is important for understanding the K^+K^- as well as Kp interactions. There is a discrepancy between the excitation function obtained from existing measurements and theoretical expectations, especially in the near-threshold region, where kaon interactions are most important. Measurement at 6 MeV excess energy for that reaction was performed with the COSY-11 detection system at the Cooler Synchrotron COSY. In the talk I will present the current status of research for this process together with the newly obtained upper limit for the total cross section at $Q = 6$ MeV.

Parallel Session C6 /

Looking for chiral anomaly in $K\gamma \to K\pi$ reactions

VYSOTSKY, Mikhail[1] ; ZHEMCHUGOV, Evgenii[1]

[1]Institute for Theoretical and Experimental Physics

Corresponding Author(s): zhemchugov@itep.ru

In an experiment currently being performed at the Institute for High Energy Physics, Serpukhov, Russia, a beam of charged kaons is directed on a copper target. In the electromagnetic field of the target nuclei two reactions occur: $K^+\gamma \to K^+\pi^0$ and $K^+\gamma \to K^0\pi^+$. A peculiar distinction between these two reactions is that there is a chiral anomaly contribution in the former reaction, but not in the latter. This contribution can be directly seen through comparison of the cross sections of these reactions near the threshold. In the talk the expressions for the cross sections will be presented.
The talk is based on arXiv:1512.04438.

Plenary Session /

Measurement of the pion mass from X-ray spectroscopy of exotic atoms

Author(s): TRASSINELLI, Martino[1]
Co-author(s): ANAGNOSTOPOULOS, Dimitrios F.[2] ; BORCHERT, Gunther[3] ; DAX, Andreas[4] ; EGGER, Jean-Pierre[5] ; GOTTA, Detlev[3] ; HENNEBACH, Maik[3] ; MANIL, Bruno[6] ; NELMS, Nick[7] ; LIU, Yi-Wei[4] ; INDELICATO, Paul[6] ; WELLS, Alan[7] ; SIMONS, Leopold M.[8]

[1]Institut des NanoSciences de Paris, CNRS, Sorbonne Universités UPMC Univ Paris 06, Paris, France

[2]Dept. of Materials Science and Engineering, University of Ioannina, Ioannina, Greece

[3]Institut für Kernphysik, Forschungszentrum Jülich GmbH, Jülich, Germany

[4]Laboratory for Particle Physics, Paul Scherrer Institut, Villigen PSI, Switzerland

[5]Institut de Physique de l' Université de Neuchâtel, Neuchâtel, Switzerland

[6]Laboratoire Kastler Brossel, CNRS, Sorbonne Universités UPMC Univ. Paris 06, ENS, Paris, France

[7]Dept. of Physics and Astronomy, University of Leicester, Leicester, England

[8]Laboratory for Particle Physics, Paul Scherrer Institut, Villigen

for the Pion mass Collaboration

Corresponding Author(s): martino.trassinelli@gmail.com

X-ray spectroscopy of exotic atoms allows the determination of the mass of short-lived negatively charged unstable particle like muons, pions, or kaons from the energies of characteristic X-ray radiation. Pions are captured by the target atoms in a highly excited state and a de-excitation cascade takes place accompanied by Auger and radiative emission. Auger emission is dominant at the beginning of the cascade process, with the shell by shell ejection of the electrons, when the X-ray emission take place mainly for lower level de-excitation. The mass of the pion is extracted by the accurate measurement of X-ray photons corresponding to transitions between levels neither affected by strong-interaction effects nor by remaining electrons. The best conditions are found in the medium part of medium Z atoms which corresponds to the few keV range for X-ray transitions.

The actual reference value of the pion mass from the Particle Data Group has an accuracy of 2.5 parts per million (ppm) and is based on two high-accuracy crystal spectroscopy of pionic magnesium and pionic nitrogen. In the case the πMg, the use of a solid target induces a continuous electron refilling during the de-excitation cascade and an assumption on the number of remaining electrons has to be done to extract the pion mass value from the $(4f - 3d)$ transition energy measurement. This is not the case when a gaseous target is used as in the measurement of πN atoms where the $(5g - 4f)$ energy transition was measured with respect to Cu˜Kα fluorescence radiation. In this case, the accuracy was limited by the complex structure of the broad copper calibration line.

Here we present a new experiment performed at the Paul Scherrer Institut that resumes the strategy of the gas target measuring the πN $(5g - 4f)$ transition but exploiting the almost coinciding narrower μO $(5g - 4f)$ transition as reference. With an uncertainty of 0.033ppm, the mass of the muon provides a very high accuracy of the reference energy (1 meV). The πN and μO transitions are measured simultaneously with a Johann-type spectrometer equipped with a spherically bent Si(220) crystal and a dedicated array of 6 x-ray CCDs. The simultaneous measurement minimizes possible systematic shifts during the unavoidably long measuring periods.

Plenary Session /

Kaonic nuclear state search at J-PARC

IWASAKI, Masahiko[1]

[1]RIKEN

Corresponding Author(s): masa@riken.jp

The $\bar{K}N$ interaction is known to be strongly attractive from low-energy scattering data [1] and X-ray spectroscopy of kaonic atoms [2]. It is widely accepted that the $\Lambda(1405)$ is K^-p bound state / penta-quark or at least strongly couple to that state. The natural expectation of this assumption is that the kaonic nuclear bound state will be formed, and accordingly, such states are predicted and the high density matter formation exceeding the normal nuclear density is expected in such states [3,4]. Therefore, observation of a kaonic nuclear bound state would provide definitive information on the $\bar{K}N$ interaction below threshold, as well as the nature of $\Lambda(1405)$. Both theoretical and experimental studies have been made in the last decade. In particular, strong attention has been paid to the simplest kaonic nuclear state $\bar{K}NN$. Theoretically, all calculations predict the existence of a bound state. However, the predicted $\bar{K}NN$ pole positions, depending on $\bar{K}N$ interaction models, are scattered. For the energy-independent model (static calculation), the binding energy is reaching up to 50-100 MeV [4-11], while in energy-dependent case, it becomes weaker to be 10-30 MeV [11-13]. The widths are also widely scattered over 30-110 MeV/c^2. Experimentally, there are many reports on observed peak structure $\sim$100 MeV below $\bar{K}NN$ threshold. The first report from FINUDA group showing a peak structure in the back-to-back Λp invariant mass spectra via the stopped kaon reaction on ^{6}Li, ^{7}Li, and ^{12}C targets [14], having binding energy (B.E.)$\sim$115 MeV, having a width (Γ)$\sim$70 MeV/c^2 . The DISTO group observed $\bar{K}NN$ decaying to Λp in pp collision at B.E. $\sim$ 100 MeV, having $\Gamma\sim$120 MeV/c^2 [15]. Conversely, no significant structure was observed in a SPring-8/LEPS γ induced inclusiveexperiment [16] or in a proton-proton interaction at HADES/GSI [17]. Also, for the kaon stopped reaction, theother interpretations (i.e. two-nucleon absorption of kaons, which have the final state (Λp or $\Sigma^0 p$) are widely discussed [18,19]. Thus, the evidence for kaonic nuclei remains controversial. To clarify the situation, two independent experimental groups, E15 and E27, are conducting experiments at J-PARC searching for $\bar{K}NN$ bound state. J-PARC E15 and E27 utilizing different reaction channels. The E15 is utilizing ^{3}He(K^-, n) reaction by K^- momentum at 1 GeV/c, while the E27 is utilizing $d(\pi^+, K^+)$ reaction by π^+ momentum at 1.7 GeV/c. The E27 was conducted much earlier than the E15, since the pion beam is more easy to obtained, and published their final result already [20]. According to their paper, they reported that they observed "K^-pp" -like structure at B.E. $\sim$100 MeV, having $\Gamma \sim$ 150 MeV/c^2 , in the $\Sigma^0 p$ decay mode. Their result on binding energy and width is not pretty much consistent with other positive results. The detected decay mode is also different. In an attempt to clarify this situation, the E15 experiment on the K^-+^3He reaction is under way at J-PARC. The first physics data E15 1st. were accumulated in May 2013. The semi-inclusive forward neutron spectrum in the E15 1st. data has a long sub-threshold tail reaching $\sim$100 MeV below the $\bar{K}NN$ threshold, but no significant structure was seen in the deeply bound region [21]. They also conducted inclusive analysis on E15 1st. data for Λpn final state. In this analysis, they used ^{3}He$(K^-, \Lambda p)n_{mis.}$ reaction channel by kinematically identifying missing neutron. They found a broad peak structure near / slightly below the $\bar{K}NN$ threshold, [22] which is quite different from all the other positive channel. To clarify this structure near the threshold, they conducted high statistic run as E15 2nd., in which they accumulated roughly 50 times data for the Λpn final state, and the analysis of E15 2nd. data is in progress. The paper covers present experimental results from these two groups at

J-PARC to search for deeply bound kaonic nuclear state, and recent progress of their analysis.
[1] A. D. Martin, Nucl. Phys. B 179 33 (1981).
[2] M. Bazzi et al., Phys. Lett. B 704, 113 (2011).
[3] Y. Akaishi and T. Yamazaki, Phys. Rev. C 65, 044005 (2002).
[4] T. Yamazaki and Y. Akaishi, Phys. Lett. B 535, 70 (2002).
[5] Y. Ikeda and T. Sato, Phys. Rev. C 79, 035201 (2009).
[6] N. V. Shevchenko, A. Gal, and J. Mares Phys. Rev. C 76, 044004 (2007).
[7] S. Wycech, and A. M. Green , Phys. Rev. C 79, 014001 (2009).
[8] A. Dote , T. Hyodo, and W. Weise, Phys. Rev. C 79, 014003 (2009).
[9] Y. Ikeda, and T. Sato, Phys. Rev. C 79, 035201 (2009).
[10] S. Maeda, Y. Akaishi, and T.Yamazaki, Proc. Jpn. Acard., Ser. B 89, 418 (2013).
[11] J. Revai, and N. V. Shevchenko, Phys. Rev. C 90, 034004 (2014).
[12] Y. Ikeda, H. Kamano, and T. Sato, prog. Theor. Phsy. 124 533 (2010).
[13] N. Barnea, A. Gal, and E. Z. Liverts, Phys. Lett. B 712 132 (2012).
[14] M. Agnello et al., Phys. Rev. Lett. 94, 212303 (2005).
[15] T. Yamazaki et al., Phys. Rev. Lett. 104, 132502 (2010).
[16] A. O. Tokiyasu et al., Phys.Lett. B 728, 616 (2014).
[17] L. Fabbietti et al., Nucl. Phys. A 914, 60 (2013).
[18] O. Vazquez Doce et al., arXiv:1511.04496 [nucl-ex] (2014).
[19] A. Filippi and S. Piano, Hyperfine Interact. 233, 151 (2015).
[20] Y. Ichikawa et al., Prog. Theor. Exp. Phys. 021D01 (2015).
[21] T. Hashimoto et al., Prog. Theor. Exp. Phys. (2015) 061D01.
[22] Y. Sada et al., arXiv:1601.06876 [nucl-ex] (2016).

Plenary Session /

Meson spectroscopy at COMPASS

GRUBE, Boris[1]

[1]Technische Universität München

for the COMPASS Collaboration

Corresponding Author(s): bgrube@tum.de

The goal of the COMPASS experiment at CERN is to study the structure and dynamics of hadrons. The two-stage spectrometer used by the experiment has good acceptance and covers a wide kinematic range for charged as well as neutral particles allowing to access a wide range of reactions. Light mesons are studied with negative (mostly π^-) and positive (p, π^+) hadron beams with a momentum of 190 GeV/c.
The light-meson spectrum is measured in different final states produced in diffractive dissociation reactions with squared four-momentum transfer t to the target between 0.1 and 1.0 (GeV/c)^2. The flagship channel is the $\pi^-\pi^+\pi^-$ final state, for which COMPASS has recorded the currently world's largest data sample. These data not only allow to measure the properties of known resonances with high precision, but also to search for new states. Among these is a new axial-vector signal, the $a_1(1420)$, with unusual properties. Novel analysis techniques have been developed to extract also the amplitude of the $\pi^+\pi^-$ sub-system as a function of 3π mass from the data. The findings are confirmed by the analysis of the $\pi^-\pi^0\pi^0$ final state.

Plenary Session /

Light meson spectroscopy at BESIII

MIN, Tianjue[1]

[1]Institute of High Energy Physics, Beijing

for the BESIII Collaboration

Corresponding Author(s): mintj@ihep.ac.cn

Light meson spectroscopy plays a crucial role in examining the QCD theory. The BESIII has collected the largest J/ψ and ψ' sample in the world, therefore provides a good chance to study light mesons by studying J/ψ and ψ' decays. In this talk, we will report recent results on light meson spectroscopy at BESIII.

Plenary Session /

Charmed meson production at LHCb

MUELLER, Dominik[1]

[1]University of Manchester

for the LHCb Collaboration

Corresponding Author(s): dominik.muller@cern.ch

The start of LHC Run 2, with proton-proton collisions at $\sqrt{s} = 13$ TeV, opens a new regime in which QCD predictions for charm meson production may be precisely tested. LHCb is uniquely suited to make these measurements in the forward region and obtained results can be used to further constrain parton distribution functions. In addition to measuring absolute production cross-sections, ratios of cross-sections at different centre-of-mass energies benefit of cancellation of both experimental and theoretical uncertainties, providing a new sensitive test of the QCD calculations. This talk aims to give an overview on charm meson production measurements by LHCb in Run 1 and Run 2 with a focus on the recent results for J/ψ and D meson production at $\sqrt{s} = 13$ TeV.

Plenary Session /

Hadronic molecules with hidden charm and bottom

GUO, Feng-Kun[1]

[1]Institute of Theoretical Physics, CAS

Corresponding Author(s): fkguo@itp.ac.cn

Since 2003, many new structures in the heavy quarkonium mass regions, dubbed XYZ, were observed in experiments. Some of them are close to thresholds of two open-flavor mesons, and were suggested to be candidates of hadronic molecules. I will discuss some of these XYZ states from the point of view of hadronic molecules.

Plenary Session /

Quarkonium and heavy flavour meson production at 13 TeV at ATLAS

GLADILIN, Leonid[1]

[1]Skobeltsyn Institute of Nuclear Physics Lomonosov Moscow State University (SINP MSU)

for the ATLAS Collaboration

Corresponding Author(s): gladilin@mail.cern.ch

First results of the ATLAS experiment at LHC on quarkonium and heavy flavour meson production in proton-proton collisions at 13 TeV are presented. A brief summary of the results obtained at 7-8 TeV is also reported. Comparison of the data cross sections with various theoretical predictions is discussed. Prospects for further studies with available and coming data are outlined.

Plenary Session /

First CMS Heavy-Flavour results at 13 TeV

RONCHESE, Paolo[1]

[1]University and INFN Padova

for the CMS Collaboration

Corresponding Author(s): paolo.ronchese@unipd.it

Measurements of b-hadron and quarkonium production cross sections provide essential information to understand QCD. This talk will show new measurements of double-differential production cross sections vs. transverse momentum pT and rapidity y at center-of-mass energy of 13 TeV performed by CMS experiment with data collected in 2015. Comparisons with results obtained at 7 TeV will be shown.

Plenary Session /

Outlook

GAL, Avraham[1]

[1]Hebrew University, Jerusalem, ISRAEL

Corresponding Author(s): avragal@savion.huji.ac.il