The 9th International Workshop on Charm Physics (CHARM18)

Monday 21 May 2018 - Friday 25 May 2018

Budker INP

Book of Abstracts

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Prospects of Charm Physics at PANDA

Dr. MESSCHENDORP, Johan[1]

[1] *KVI-CART*

Corresponding Author(s): j.g.messchendorp@rug.nl

The ambition of the antiProton ANnihilation at DArmstadt (PANDA) collaboration is to address various questions related to the strong interactions by employing a multi-purpose detector system at the near-future Facility for Antiproton and Ion Research (FAIR). The usage of antiprotons with unprecedented momentum resolution and intensity will give access to a unique physics program. With center-of-mass energies up to 5.5˜GeV, PANDA will be able to probe various aspects of QCD from light to charm-like systems. In this presentation, I will give an overview and motivation of the overall physics program of PANDA at FAIR with emphasis on the prospects of studying hidden- and open-charm(like) hadrons in the first phase of data taking.

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A project of Super-charm-tau Factory in Novosibirsk

Corresponding Author(s): e.b.levichev@inp.nsk.su

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Prospects of Charm Physics with Belle II

Corresponding Author(s): giulia.casarosa@pi.infn.it

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LHCb upgrade and prospects of Charm Physics

Corresponding Author(s): adzyuba@cern.ch

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HIEPA - Super-tau-charm Factory in China

Corresponding Author(s): penghp@ustc.edu.cn

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Prospects of Charm Physics at ATLAS

Corresponding Author(s): semen.turchikhin@cern.ch

Charmed Meson and Baryon Spectroscopy / 58

Doubly-charmed baryons at LHCb

Dr. EVANGELHO VIEIRA, Daniel[1]

[1] *University of Chinese Academy of sciences*

Corresponding Author(s): devieira@ucas.ac.cn

The first observation of the doubly charmed baryon was reported by LHCb collaboration in 2017. The ongoing studies of the Ξ_{cc} properties within the LHCb collaboration are presented.

Charmed Meson and Baryon Spectroscopy / 54

Charmed hadron spectroscopy at Belle

Prof. WANG, Xiaolong[1]

[1] *Fudan University*

Corresponding Author(s): xiaolong@fudan.edu.cn

Using the 980 fb^{-1} full data sample taken with the Belle detector, there are measurements finished recently. Studies of charmed hadron spectroscopy, especially the baryons, from Belle experiment are presented. A strange pentaquark state has been searched for in $\Lambda_C \to \pi^0 p\Phi$. Branching fraction of hadron decays of Ω_c have been measured. There is observation of $\Xi_c(2930)$ in Λ^+K^- final states. Belle confirmed the excited Ω_c states observed by LHCb. Production rates of various baryons is also studied.

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Theoretical Aspects of Charmed Baryons

Prof. MATHUR, Nilmani[1]

[1] *Tata Institute of Fundamental Research*

Corresponding Author(s): nilmani@theory.tifr.res.in

The study of heavy hadrons is passing through an incredible era with the discovery of numerous heavy subatomic particles. The study of charm baryons is an integral part of this resurgence in scientific interest to explore the spectrum of strongly interacting heavy hadrons. I will present theoretical aspects of charmed baryons with emphasis on results from lattice calculations.

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Open bottom tetraquarks and their relation to doubly charmed baryons

Corresponding Author(s): randy.lewis@yorku.ca

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Lambda_c Physics at BESIII

Corresponding Author(s): xiaorui@ucas.ac.cn

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Charmed Hadron Spectroscopy at LHCb

Corresponding Author(s): patrick.spradlin@cern.ch

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Status of Charmed Meson Spectroscopy

Prof. GUO, Feng-Kun[1]

[1] *Institute of Theoretical Physics, Chinese Academy of Sciences*

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

In this talk, I will review the status of charmed meson spectroscopy, paying particular attention to the recent progress made using effective field theories and lattice QCD.

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Experimental Status of Conventional Charmonium Spectroscopy

Dr. WANG, Xiongfei[1]

[1] *Institute of High Energy Physics*

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

In this talk, I will present most recent experimental status on conventional charmonium spectroscopy based on the data collected from the BESIII, Belle, LHCb and KEDR Collaborations. These include improved measurements of two-photon widths of χ_{cJ} states and helicity analysis $\chi_{c2} \to \gamma\gamma$, $\chi_{c1,2}$ resonance parameters with the decays $\chi_{c1,2} \to J/\psi\mu^+\mu^-$, and η_c resonance parameters measurement, the J/ψ decay widths measurement, determination of J/ψ and $\psi(2S)$ masses, observations of $X(3823)$ and $X(3860)$.

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Charmonium at KEDR

Mrs. KHARLAMOVA, Tatyana[1]

[1] *BINP, NSU*

Corresponding Author(s): t.a.kharlamova@inp.nsk.su

We report new precise results of experiments performed with the KEDR detector at the VEPP-4M e+e- collider. They include final results for J/ψ and ψ(2S) parameters and R measurement. Cross sections for the processes e+e- →hadrons and e+e- → e+e- were measured at J/ψ resonance energy range and leptonic width of J/ψ meson and its composition to hadronic and electronic branching fractions were obtained with accuracy less than 2%. The product of the electronic width of the ψ(2S) meson and the branching fraction of its decay to the muon pair was measured in the e+e−→ψ(2S)→μ+μ− process with the world best accuracy about 3%. Leptonic width of ψ(2S) meson was calculated, using the previous KEDR measurements with the lepton universality assumption and without it. Recently the R was measured in the center-of-mass energy between 3.0 and 3.8 GeV with the total accuracy up to 2.6%.

D oscillations and CP Violation / 50

Review of recent developments on leptonic and semileptonic charm decays from lattice QCD

Dr. SALERNO, Giorgio[1]

[1] *University of Roma Tre & LPT Orsay*

Corresponding Author(s): giorgio.salerno.phys@gmail.com

Leptonic and semileptonic decays of charmed mesons are excellent places for the extraction of the CKM matrix elements $|V_{cd}|$ and $|V_{cs}|$ and to provide stringent constraints on possible New Physics scenarios. Lattice QCD provides a non-perturbative method to calculate the hadronic contributions involved in these processes. In this talk, I will review recent progress in the

study of D-meson decay constants and semileptonic form factors. In addition, I will present the impact of the latest lattice-QCD results on phenomenology and compare the predictions with the experimental results.

D oscillations and CP Violation / 102

Mixing and CPV measurements at the B-factories

Corresponding Author(s): chenyq15@mail.ustc.edu.cn

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Searches for direct CPV in charm at LHCb

Corresponding Author(s): maxime.schubiger@epfl.ch

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Rare charm decays at LHCb

Corresponding Author(s): dmitzel@cern.ch

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D mixing parameter y in the factorization-assisted topological-amplitude approach

Dr. QIN, Qin[1]

[1] *University of Siegen*

Corresponding Author(s): qin.qin@uni-siegen.de

We calculate the $D^0 - \overline{D}^0$ mixing parameter y in the factorization-assisted topological-amplitude (FAT) approach, considering contributions from $D^0 \to PP$, PV, and VV modes, where P (V) stands for a pseudoscalar (vector) meson. The $D^0 \to PP$ and PV decay amplitudes are extracted in the FAT approach, and the $D^0 \to VV$ ones with final states in the longitudinal polarization are estimated via the parameter set for $D^0 \to PV$. It is found that the VV contribution to y, being of order of 10^{-4}, is negligible, and that the PP and PV contributions amount only up to $y_{PP+PV} = (0.21 \pm 0.07)\%$, a prediction more precise than those obtained in the literature, and much lower than the experimental data $y_{\rm exp} = (0.61 \pm 0.08)\%$. We conclude that D^0 meson decays into other two-body and multi-particle final states are relevant to the evaluation of y, so it is difficult to have its full understanding in an exclusive approach.

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XYZ states as hadronic molecules

Dr. NEFEDIEV, Alexey[1]

[1] *Lebedev Physical Institute*

Corresponding Author(s): nefediev@lebedev.ru

In the past decade, a lot of new hadrons containing heavy quarks were discovered which do not fit into the scheme provided by the traditional quark models. Such states are known as the XYZ states and they are traditionally referred to as exotic ones. At present, there is no consensus on

their nature, and different models and approaches have been suggested to explain their unusual properties. The talk is devoted to a brief overview of the molecule model for such exotic states.

Exotics / 53

Penta-quarks with hidden charm and their strange beauty partners

Prof. ZOU, Bingsong[1]

[1] *Institute of Theoretical Physics, CAS*

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

I will introduce some interesting progress on Penta-quarks with hidden charm and their strange beauty partners

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Heavy hybrids and tetraquarks in EFT

Dr. TARRUS CASTELLA, Jaume[1]

[1] *IFAE*

Corresponding Author(s): jaumetarrus@gmail.com

In the past decade a large amount of unexpected states have been discovered in the charmonium and bottomonium spectra. These states are candidates for nontraditional hadronic states including four quarks or gluonic excitations as constituents. Many of these states can be identified as heavy quark-antiquark bound states in gluonic and light-quark static energies. In this talk I elaborate on an effective field theory approach that takes inspiration from the Born-Oppenheimer approximation that can be used to describe these exotic states with input from lattice QCD. Results for the hybrid spectrum including spin-dependent contributions and semi-incusive decays into quarkonia will be reviewed.

Exotics / 61

Charmonium and exotics from lattice QCD

Prof. KNECHTLI, Francesco[1]

[1] *University of Wuppertal*

Corresponding Author(s): knechtli@physik.uni-wuppertal.de

We review selected lattice results on the charmonium spectrum and first attempts to search for the existence of exotic states. The hadro-quarkonium model was proposed to interpret some of the exotic states as a quarkonium core inside a hadron. We present a lattice study of the hadro-quarkonium model in the limit of static quarks. The charm quark decouples in low energy observables and binding energies of charmonium. In a model calculation we are able to evaluate the corrections to decoupling of the charm quark in the continuum.

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Charm and exotic hadrons from BES III

Prof. YUAN, Changzheng[1]

[1] *IHEP, Beijing*

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

The recent results on the study of the charmoniumlike states at the BESIII experiment will be presented, including the cross sections of e+e- to pi+pi-J/psi, pi+pi-hc, pi+pi-psi', pi+pi-psi", pi+pi-pi0eta_c, K+K-J/psi and the intermediate states in these modes, the cross sections of e+e- to eta J/psi, eta' J/psi, eta hc, phi chi_c, gamma eta_c, gamma X(3872), and so on. Perspectives of the studies of exotics at BESIII will also be shown.

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XYZ at the upgraded LHCb

Corresponding Author(s): tskwarni@syr.edu

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XYZ at Belle II

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

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XYZ states as compact tetraquarks

Corresponding Author(s): antonio.polosa@roma1.infn.it

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Complementarity of beauty and charm hadron physics

Corresponding Author(s): A.E.Bondar@inp.nsk.su

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Charm and exotic hadrons from LHCb

Corresponding Author(s): anton.poluektov@cern.ch

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Charm and exotic hadrons from B factories

Corresponding Author(s): solsensnu@gmail.com

Hidden and Open Charm in Media / 24

Theoretical overview of charmonium evolutions in the hot medium

Author(s): Dr. CHEN, BAOYI[1]
Co-author(s): Prof. ZHUANG, Pengfei [2] ; Prof. GREINER, Carsten [3] ; Prof. ZHA, Wangmei [4]

[1] *Tianjin University*

[2] *Tsinghua University*

[3] *Frankfurt University*

[4] *USTC*

Corresponding Author(s): chen.bao.yi.phy@gmail.com

I will discuss about both J/ψ and $\psi(2S)$ evolutions in different systems (p-Pb, Pb-Pb), focusing on the aspects of (1) J/ψ regeneration connected with charm diffusion and thermalization in the expanding QGP, (2) double ratio $R_{AA}^{\psi(2S)}/R_{AA}^{J/\psi}$ and transitions between J/ψ and $\psi(2S)$ induced by color screening effect on heavy quark potential, (3) charmonium photoproduction from initial electromagnetic fields even in semi-central collisions $b \sim R_A$ (with the existence of QGP), (4) and different final state interactions for J/ψ and $\psi(2S)$ in small system p-Pb as a function of rapidity and p_T. Different theoretical models involving above topics will also be briefly introduced and compared.

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Measurements of multiplicity dependence of heavy-flavour hadron production in small systems and azimuthal correlations with charged particles with ALICE at the LHC

MAZZILLI, Marianna[1]

[1] *Università and INFN of Bari*

Corresponding Author(s): marianna.mazzilli@cern.ch

The ALICE detector is devoted to study the properties of the Quark-Gluon Plasma (QGP), a deconfined state of hadronic matter produced in ultra-relativistic heavy-ion collisions at the LHC. Due to their large masses, heavy quarks (charm and beauty) are produced in the early stages of the collision through hard parton scatterings, and their abundances are preserved during the subsequent collision stages. Hence, they experience the whole evolution of the QGP medium and are effective probes for its characterisation.

Measurements of the multiplicity dependence of heavy-flavour hadron production and their angular correlations with charged particles provide constraints on the description of heavy-flavour production in pp, p-Pb and Pb-Pb collisions. In particular, the measurement of heavy-flavour production in pp collisions as a function of the charged-particle multiplicity provides insights into the role of multi-parton interactions and the interplay between hard and soft mechanisms in particle production. The multiplicity-differential measurements of heavy-flavour production in p–Pb collisions are sensitive to the dependence of cold nuclear matter (CNM) effects on the collision geometry and on the density of final-state particles. Furthermore, the measurement of azimuthal correlations of heavy-flavour hadrons with charged particles, in pp collisions, provides a way to characterize charm production and fragmentation processes, while in p–Pb collisions it could give insights into possible collective effects in small systems. Studies in Pb–Pb collisions allow accessing the properties of the Quark-Gluon Plasma (QGP).

In this contribution, the measurements of the yields of heavy-flavour hadrons as a function of charged-particle multiplicity in pp and in p–Pb collisions will be shown together with the azimuthal correlations with charged particles in pp, p–Pb and Pb–Pb collision systems. In particular, the elliptic-flow (v_2) of heavy-flavour hadron decay electrons in high-multiplicity p-Pb collisions will be discussed. Finally, the results obtained from the azimuthal correlation of heavy-flavour decay electrons with charged particles in Pb-Pb collisions and from D mesons with charged particles in pp and p-Pb collisions will be shown.

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Charmonia at nonzero temperature from high precision lattice QCD computations

Mr. SHU, Hai-Tao[1]

[1] *ccnu*

Corresponding Author(s): haitaoshu@mails.ccnu.edu.cn

The fate of the charmonia as well as the charm quark diffusion coefficients at nonzero temperature are important to understand the observed nuclear modification factors of charmonia as well as open charm mesons in heavy ion collision experiments.
In this talk, we will present our recent results on charmonia spectral functions obtained from quenched lattice QCD simulations at $T \in [0.35, 2.25]T_c$. The simulations have been performed on very large and fine lattices where charm quarks can be treated relativistically. We will start by showing the temperature dependence of charmonia correlation functions at several temperatures above and below the deconfinement temperature. We will then discuss the temperature dependences of spectral functions and the resulting charm quark diffusion coefficients obtained from the Maximum Entropy Method. Finally we will present the results on the screening masses of charmonia as well as the dispersion relation at nonzero momenta.

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Experimental review of Open Charm in pA collisions

Corresponding Author(s): a.grelli@uu.nl

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Experimental review of Open Charm in AA collisions

Corresponding Author(s): xzhang@cern.ch

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Open charm in heavy-ion collisions

Corresponding Author(s): magda@ipb.ac.rs

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Experimental review of Quarkonium Production in pA collisions

Corresponding Author(s): robbe@lal.in2p3.fr

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Effective field theory calculations in open charm and charmonium production in media

Dr. ESCOBEDO ESPINOSA, Miguel Ángel[1]

[1] *University of Jyväskylä*

Corresponding Author(s): miguel.a.escobedo-espinosa@jyu.fi

Heavy quarkonium related observables are very useful to obtain information about the medium created in relativistic heavy ion collisions. The interaction of charmonium or bottomonium with the hot QCD medium created in these collisions can be efficiently described with the use of non-relativistic Effective Field Theories. In this talk I will review recent progress in understanding quarkonium dynamics in a thermal medium with the use of potential non-relativistic QCD (pNRQCD). First I will discuss the medium modifications of the decay width and the binding energy. Using pNRQCD power counting it is possible to identify in which temperature regimes

a potential model can describe these modifications and what is the dominant physical process behind the thermal corrections in each case. After that I will discuss the combination of pNRQCD with open quantum systems techniques. This allows to make predictions about the nuclear modification factor that can be compared with experimental measurements.

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Experimental review of Quarkonium Production in AA collisions

Prof. TANG, Zebo[1]

[1] *University of Science and Technology of China*

Corresponding Author(s): zbtang@ustc.edu.cn

One of the major goals of heavy-ion collisions is to search for quark-gluon plasma (QGP) and study its properties. Quarkonium, the bound state of heavy quarks, provides a sensitive probe of QGP because its production yield in QGP is modified by the color-screening effect, heavy quark (re)combination effect etc.
In this talk, I will overview the quarkonium results in heavy-ion collisions from the ongoing experimental efforts at RHIC and LHC. The physics implications will also be discussed.

Leptonic, Semileptonic, Radiative and Rare Charm Decays / 20

Study of D_s decays at BESIII

Dr. MURAMATSU, Hajime[1]

[1] *University of Minnesota*

Corresponding Author(s): hajime.muramatsu@gmail.com

BESIII has now collected the world's largest e^+e^- annihilation samples taken at $E_{cm} = 4.009$ and 4.178 GeV, which contain copious charmed-strange mesons. In this talk, I report our recent studies on leptonic and semileptonic decays of the D_s meson, which allow us to extract the CKM matrix elements $|V_{cs(d)}|$ and the decay constants $f_{D_s^+}$ or semileptonic form factors. Our recent preliminary results on D_s hadronic decays are also presented, including $D_s^+ \to p\bar{n}$.

Leptonic, Semileptonic, Radiative and Rare Charm Decays / 21

Leptonic, semi-leptonic, and rare charm decays at the B-factories

Mr. LEVIT, Dmytro[1]

[1] *Technical University of Munich*

Corresponding Author(s): dmytro.levit@tum.de

The B factories, Belle and BaBar, were successful in measuring the properties of the B mesons. But the B factories also produce a similar number of D mesons in the electron-positron collisions. The data sets recorded at the B factories allow us to study leptonic, semi-leptonic, and rare D decays. These decays are suppressed in the Standard Model. Therefore, the comparison of the observables extracted from these decays to the Standard Model predictions makes them a useful instrument in the search for new physics. In this contribution I will present an overview of the measurements performed at the B factories.

Leptonic, Semileptonic, Radiative and Rare Charm Decays / 100

Rare charm decays

Corresponding Author(s): apetrov@wayne.edu

Leptonic, Semileptonic, Radiative and Rare Charm Decays / 101

HFLAV: results on charm mixing and CPV

Corresponding Author(s): alan.j.schwartz@uc.edu

Leptonic, Semileptonic, Radiative and Rare Charm Decays / 2

Short-distance matrix elements for D^0-meson mixing from $N_f = 2 + 1$ lattice QCD

Author(s): Dr. CHANG, Chia Cheng[1]
Co-author(s): Prof. BAZAVOV, Alexei [2] ; Dr. KRONFELD, Andreas [3] ; Prof. LAIHO, Jack [4] ; Dr. MACKENZIE, Paul [3] ; Prof. NEIL, Ethan [5] ; Dr. SIMONE, James [3] ; Prof. SUGAR, Robert [6] ; Prof. TOUSSAINT, Doug [7] ; Dr. VAN DE WATER, Ruth [3] ; Dr. ZHOU, Ran [3] ; Dr. DU, Daping [4] ; Prof. BERNARD, Claude [8] ; Prof. BOUCHARD, Chris [9] ; Prof. DETAR, Carleton [10] ; Prof. EL-KHADRA, Aida [11] ; Prof. FREELAND, Elizabeth [12] ; Prof. GAMIZ, Elvira [13] ; Prof. GOTTLIEB, Steven [14] ; Prof. HELLER, Urs [15]

[1] *Lawrence Berkeley National Laboratory*

[2] *MSU*

[3] *FNAL*

[4] *Syracuse University*

[5] *University of Colorado, Boulder*

[6] *UCSB*

[7] *University of Arizona*

[8] *Washington University in St. Louis*

[9] *University of Glasgow*

[10] *University of Utah*

[11] *University of Illinois at Urbana-Champaign*

[12] *School of the Art Institute of Chicago*

[13] *Universidad de Granada*

[14] *Indiana University*

[15] *APS*

Corresponding Author(s): chiachang@lbl.gov

We calculate in three-flavor lattice QCD the short-distance hadronic matrix elements of all five $\Delta C = 2$ four-fermion operators that contribute to neutral D-meson mixing both in and beyond the Standard Model. We use the MILC Collaboration's $N_f = 2 + 1$ lattice gauge-field configurations generated with asqtad-improved staggered sea quarks. We also employ the asqtad action for the valence light quarks and use the clover action with the Fermilab interpretation for the charm quark. We analyze a large set of ensembles with pions as light as $M_\pi \approx 180$ MeV and lattice spacings as fine as $a \approx 0.045$ fm, thereby enabling good control over the extrapolation to the physical pion mass and continuum limit. We obtain for the matrix elements in the $\overline{\rm MS}-{\rm NDR}$ scheme using the choice of evanescent operators proposed by Beneke \emph{et al.}, evaluated at 3 GeV, $\langle D^0|\mathcal{O}_i|\bar{D}^0\rangle = \{0.0805(55)(16), -0.1561(70)(31), 0.0464(31)(9), 0.2747(129)(55), 0.1035(71)(21)\}\ GeV^4$ ($i = 1$ - 5). The errors shown are from statistics and lattice systematics, and the omission of charmed sea quarks, respectively. To illustrate the utility of our matrix-element results, we place bounds on the scale of CP-violating new physics in D^0 mixing, finding lower limits of about 10 - 50×10^3 TeV for couplings of O(1). To enable our results to be employed in more sophisticated or model-specific phenomenological studies, we provide the correlations among our matrix-element results. For convenience, we also present numerical results in the other commonly-used scheme of Buras, Misiak, and Urban.

Leptonic, Semileptonic, Radiative and Rare Charm Decays / 98

Charm semileptonic decays at LHCb

Corresponding Author(s): alberto.lusiani@pi.infn.it

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D leptonic, semileptonic and rare decays at BESIII

Corresponding Author(s): zhangyu213@mails.ucas.ac.cn

Leptonic, Semileptonic, Radiative and Rare Charm Decays / 43

Mixing and indirect CPV charm measurements at LHCb

Prof. CARBONE, Angelo[1]

[1] *University and INFN Bologna*

Corresponding Author(s): angelo.carbone@unibo.it

Mixing and CP violation in charm LHCb has collected the world's largest sample of charmed hadrons. World's most precise measurements of neutral D-meson mixing parameters and searches for indirect CP violation in charm interactions are presented.

Light Hadronic Spectroscopy from Decays of Charm and Charmonia / 59

Light hadron spectroscopy at BESIII

Prof. FANG, Shuangshi[1]

[1] *Institute of High Energy Physics*

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

The BESIII experiment at the electron-positron collider BEPCII is successfully operating since 2008 and has collected large data samples in the tau-mass region, including the world's largest data samples at the J/ψ and $\psi(2S)$ resonances. In particular, decays of them provide a rich and clean environment to study hadrons consisting out of light quarks and search for exotics. In this presentation recent results of the light hadron physics program will be highlighted.

Light Hadronic Spectroscopy from Decays of Charm and Charmonia / 31

Light hadron spectroscopy at BESIII

Dr. DENISENKO, Igor[1]

[1] *JINR*

Corresponding Author(s): idenisen@cern.ch

The BESIII collaboration has collected unprecedentedly large data sets from e^+e^- collisions in the C.M.S energy range 2-4.6 GeV. These data, in particular 1.3×10^9 J/ψ decays and 0.4×10^9 $\psi(3686)$ decays, provide a unique environment to study light hadron spectra and to search for exotic states. The talk will cover recent BESIII results including investigation of $X(1835)$, search for glueball states in radiative J/ψ decays, observation of $e^+e^- \to \eta Y(2175)$ at center-of-mass energies above 3.7 GeV, observation of $a_0(980)$-$f_0(980)$ mixing.

Light Hadronic Spectroscopy from Decays of Charm and Charmonia / 95

Form factors of baryons and light hadrons at Belle (cancelled)

Corresponding Author(s): niiyama@rcnp.osaka-u.ac.jp

Light Hadronic Spectroscopy from Decays of Charm and Charmonia / 94

Review of recent results on amplitude analyses

Corresponding Author(s): timothy.david.evans@cern.ch

Parallel Session I / 26

Angular analysis of the $e^+e^- \to D^{(*)}D^*$ process near the open-charm threshold using initial-state radiation

Ms. ZHUKOVA, Valentina[1]

[1] *LPI*

Corresponding Author(s): zhukova.valentina07@gmail.com

New results are obtained for the exclusive cross sections of the e^+e^- annihilation into charmed hadron pairs with initial state radiation. The analysis is based on the data sample collected with the Belle detector with the integrated luminosity of 951 fb^{-1}. The accuracy of the cross section measurement is increased by a factor of 2 compared with the previous Belle study and, for the first time, the $e^+e^- \to D^*D^*$ cross section is decomposed into three components corresponding to different helicities of the D^*'s in the final state.

Parallel Session I / 32

Properties of $Z_b(10610)$ and $Z_b(10650)$ from an analysis of experimental line shapes

Author(s): Dr. BARU, Vadim[1]
Co-author(s): Dr. NEFEDIEV, Alexey [2] ; Dr. FILIN, Arseniy [3] ; Dr. HANHART, Christoph [4] ; Dr. WANG, Qian [5]

[1] *HISKP, Bonn University*

[2] *Lebedev Physical Institute*

[3] *Ruhr-University Bochum*

[4] *FZ-Juelich*

[5] *HISKP, University of Bonn*

Corresponding Author(s): vbaruru@gmail.com

The experimental line shapes available in the $B\bar{B}^*$, $B^*\bar{B}^*$, $h_b(1P)\pi$ and $h_b(2P)\pi$ channels are analysed using a theoretical EFT-based framework manifestly consistent with unitarity and analyticity. The line shapes are calculated using a system of coupled channel integral equations with the potential consisting of the one-pion and one-eta meson exchange interactions from the lightest Goldstone boson octet as well as of several contact terms at leading and subleading orders which are adjusted to minimise the overall chi squared. The pole positions of the $Z_b(10610)$ and $Z_b(10650)$ are extracted for the best fits corresponding to chi squared of the order of one. The role of the long and intermediate range pion and eta dynamics, as well as of the effects violating heavy quark spin symmetry, is discussed. Insights for the corresponding charmonium-like states Z_c's are considered.

Parallel Session I / 30

Exclusive open-charm near-threshold cross sections in a coupled-channel approach

Dr. UGLOV, Timofey[1]

[1] *LPI RAS*

Corresponding Author(s): uglov.timofey@gmail.com

Data on 7 open-charm channels collected by the Belle Collaboration are analyzed simultaneously using a unitary approach based on a coupled-channel model in a wide energy range $\sqrt{s}$ =3.7-4.7˜GeV. The resulting fit provides a remarkably good overall description of the line shapes in all studied channels. Parameters of 5 vector charmonium resonances are extracted from the fit. It is demonstrated, that this approach could be used account for all exclusive channels and thus solve the long-term problem of the charmonium spectra near threshold.
The talk is based on "Exclusive open-charm near-threshold cross sections in a coupled-channel approach" by T. Uglov et all JETP Lett. 105 (2017) no.1, 1.

Parallel Session I / 6

Lattice Predictions for Bound Heavy Tetraquarks

Dr. FRANCIS, Anthony[1] ; Prof. LEWIS, Randy[2] ; Prof. MALTMAN, Kim[2] ; Dr. HUDSPITH, Renwick James[3]

[1] *CERN*

[2] *York University, Toronto*

[3] *York University*

Corresponding Author(s): anthony.francis@cern.ch

We investigate the possibility of $qq'\bar{Q}\bar{Q}'$ tetraquark bound states using $n_f = 2 + 1$ lattice QCD with pion masses $\simeq$ 164, 299 and 415 MeV. Two types of lattice interpolating operator are chosen, reflecting first diquark-antidiquark and second meson-meson structure. Performing variational analysis using these operators and their mixings, we determine the ground and first excited states from the lattice correlators. Using non-relativistic QCD to simulate the bottom quarks and the Tsukuba formulation of relativistic heavy quarks for charm quarks, we study the $ud\bar{b}\bar{b}$, $\ell s\bar{b}\bar{b}$ as well as $ud\bar{c}\bar{b}$, channels with $\ell = u, d$. In the case of the $ud\bar{b}\bar{b}$ and $\ell s\bar{b}\bar{b}$ channels unambiguous signals for $J^P = 1^+$ tetraquarks are found with binding energies 189(10) and 98(7) MeV below the corresponding free two-meson thresholds at the physical point. These tetraquarks are therefore strong-interaction stable, implying they are stable under strong as well as electromagnetic interactions while they can decay weakly. So far these are the first exotic hadrons predicted to have this feature. Further evidence for binding is found in the $ud\bar{c}\bar{b}$ channel, whereby the binding energy broadly straddles the electromagnetic stability threshold. Studying further the quark mass dependence we vary the heavy quark mass in $ud\bar{Q}\bar{Q}$, $\ell s\bar{Q}\bar{Q}$ as well as $ud\bar{Q}\bar{b}$, $\ell s\bar{Q}\bar{b}$ between roughly 0.7 and 6.3 times the bottom quark mass. The observed mass dependence of these four flavor channels closely follows a behaviour argued from phenomenological considerations of the heavy quark potential.

Parallel Session I / 11

Pole position of the $a_1(1260)$ in the τ decay

Dr. MIKHASENKO, Mikhail[1]

[1] *HISKP, Universität Bonn*

Corresponding Author(s): mikhail.mikhasenko@gmail.com

The discrepancy between different determinations of mass and width of the ground axial-vector state $a_1(1260)$ is a long-standing issue. Measurements include the resonance production in hadronic processes, i.e. central production, antiproton-proton annihilation, and diffraction experiments, with COMPASS providing the most accurate determination of Breit-Wigner parameters so far.

On the other end, the cleanest source of the hadron axial sector $J^{PC} = 1^{++}$ is leptoproduction in the reaction $\tau \to 3\pi\,\nu_\tau$ where the most precise data were collected by CLEO and ALEPH experiments. In order to establish an agreement, we analyze the data using analyticity and unitarity constraints and characterize the resonance by its pole position.
In this talk, we report on an analysis of the 3π spectrum from τ decays measured by the ALEPH experiment. We also accomplished the analytical continuation of the spectral function, which is a delicate procedure as it deals with the three-body final state. I will present the results for the $a_1(1260)$ resonance pole position extracted for the first time and discuss systematic uncertainties.

Parallel Session I / 12

Study of charmoniumlike states by amplitude analyses at Belle

Dr. CHILIKIN, Kirill[1]

[1] *LPI RAS*

Corresponding Author(s): chilikin@lebedev.ru

A review of charmoniumlike state studies by means of amplitude analyses at Belle is presented, including the analyses of $\bar{B}^0 \to \psi(2S)\pi^+K^-$, $\bar{B}^0 \to J/\psi\pi^+K^-$. The analysis of $e^+e^- \to J/\psi D\bar{D}$ is discussed in more detail. Prospects of similar analyses at Belle II are mentioned.

Parallel Session I / 15

Disclosing $D^*\bar{D}^*$ molecular states in the $B_c^- \to \pi^- J/\psi\omega$ decay

Author(s): Dr. MORAIS DIAS, Jorgivan[1]
Co-author(s): Mrs. DAI, Liang-Rong [2] ; Dr. OSET, Eulogio [3]

[1] *Institute of Physics, University of São Paulo, Brazil*

[2] *Department of Physics, Liaoning Normal University*

[3] *Departamento de Física Teórica and IFIC, Institutos de Investigación de Paterna, Centro Mixto Universidad de Valencia-CSIC*

Corresponding Author(s): jdias@if.usp.br

In this work, we have studied the $B_c^- \to \pi^- J/\psi\omega$ and $B_c^- \to \pi^- D^*\bar{D}^*$ reactions. In particular, we have shown they are related by the presence of two resonances: the $X(3940)$ and $X(3930)$, which are of molecular nature and couple mostly to $D^*\bar{D}^*$, but also to $J/\psi\omega$. Because of that, in the $J/\psi\omega$ mass distribution we find a cusp with large strength at the $D^*\bar{D}^*$ threshold and predict the ratio of strengths between the peak of the cusp and the maximum of the $D^*\bar{D}^*$ distribution close to $D^*\bar{D}^*$ threshold, which are distinct features of the molecular nature of these two resonances.

Parallel Session II / 29

Prediction on the discovery channel of doubly charmed baryon

Dr. YU, Fu-Sheng[1]

[1] *Lanzhou University*

Corresponding Author(s): yufsh@lzu.edu.cn

We systematically investigate the weak decays of the doubly charmed baryons, which are helpful for experimental searches for these particles. The branching fractions are studied under the factorization hypothesis for the short-distance contributions and considering the rescattering effect for the long-distance contributions which are significantly enhanced. Comparing all the decay modes, we recommend the processes of $\Xi_{cc}^{++} \to \Lambda_c^+ K^-\pi^+\pi^+$ and $\Xi_c^+\pi^+$ as the first priority

for experiments to search for the doubly heavy baryons. The LHCb collaboration successfully observed the first double-charm baryon via the decay mode $\Xi_{cc}^{++} \to \Lambda_c^+ K^- \pi^+ \pi^+$ under our suggestion.

Parallel Session II / 89

Double-heavy baryons

Corresponding Author(s): Anatolii.Likhoded@ihep.ru

Parallel Session II / 103

Direct production of chi_c1 at the e+e- collider BES III

Dr. GUO, Yuping[1]

[1] *Institut für Kernphysik,Johannes Gutenberg-Universität Mainz*

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

Up to now, only resonances with $J^{PC} = 1^{--}$ have been observed in electron-positron annihilation, while $C = +1$ resonances appear only among the decay products. The direct production of 1^{++} states could happen through two virtual photon. Due to the smallness, this process has never been verified experimentally. Given the high luminosity at the BESIII experiment, a search of direct production of χ_{c1} is undergoing with dedicated data samples around the χ_{c1} mass region. We will present an overview of the data analysis.

Parallel Session II / 33

Implication of chiral symmetry on the heavy-light spectroscopy

Author(s): Dr. DU, Meng-Lin[1]
Co-author(s): Dr. ALBALADEJO, Miguel [2] ; Prof. GUO, Feng-Kun [3] ; Mr. FERNANDEZ-SOLER, Pedro [4] ; Prof. MEISSNER, Ulf-G. [1] ; Prof. HANHART, Christoph [5] ; Dr. YAO, De-Liang [4] ; Prof. NIEVES, Juan [4]

[1] *Helmholtz-Institut f\"ur Strahlen- und Kernphysik and Bethe Center for Theoretical Physics, Universit\"at Bonn*

[2] *Departamento de F\'\i sica,Universidad de Murcia*

[3] *Institute of Theoretical Physics, Chinese Academy of Sciences*

[4] *Instituto de F\'isica Corpuscular (IFIC), Centro Mixto CSIC-Universidad de Valencia, Institutos de Investigaci\'on de Paterna*

[5] *Institute for Advanced Simulation, Institut f\"ur Kernphysik and J\"ulich Center for Hadron Physics, Forschungszentrum J\"ulich*

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

Understanding the hadron spectrum is one of the premier challenges in particle physics. For a long time, the quark model has served as an ordering scheme and brought systematics into the hadron zoo. However, many new hadrons that were observed since 2003, including the lowest-lying positive-parity charm-strange mesons $D_{s0}^*(2317)$ and $D_{s1}(2460)$, do not conform with quark model expectations. Various modifications to the quark model and alternative approaches have been proposed ever since to explain their low masses and decay properties. We demonstrate that if the lightest scalar (axial vector) states are assumed to owe their existence to non-perturbative $\pi/\eta/K$-$D^{(*)}/D_s^{(*)}$ scattering, various puzzles in the D-meson spectrum get resolved. Most importantly the ordering of the lightest strange and non-strange scalars becomes natural. We show the well constrained amplitudes for Goldstone-Boson-D/D^* scattering are fully consistent with recent high quality data on $B^- \to \pi^-\pi^- D^+$ final states. This implies that the lowest quark-model positive-parity charm mesons, together with their bottom cousins, if realized in nature, do not form the ground-state multiplet. This is similar to the pattern that has been established for

the scalar mesons made from light up, down and strange quarks, where the lowest multiplet is considered to be made of states not described by the quark model. In a broader view, the hadron spectrum must be viewed as more than a collection of quark model states.

Parallel Session II / 63

Double heavy tri-hadron bound state via delocalized π bond

Dr. MA, Li[1]

[1] *Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn*

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

The number of exotic candidates which are beyond the conventional quark model has grown dramatically during the last decades. Some of them could be viewed as analogues of the deuteron. Similarly, the existence of the triton indicates that bound states formed by three hadrons could also exist. To illustrate this possibility, we study the DD^*K and $BB^*\bar{K}$ systems by using the Born-Oppenheimer Approximation. To leading order, only one-pion exchange potentials are considered, which means that the three constitutes share one virtual pion. That is similar to the role of the delocalized π bond for the formation of Benzene in chemistry. After solving the Schr\"odinger equation, we find two three-body DD^*K and $BB^*\bar{K}$ bound states with masses $4317.92^{+3.66}_{-4.32}$ MeV and $11013.65^{+8.49}_{-8.84}$ MeV, respectively. The masses of their $D\bar{D}^*K$ and $B\bar{B}^*\bar{K}$ analogues are $4317.92^{+6.13}_{-6.55}$ MeV and $11013.65^{+8.68}_{-9.02}$ MeV. From the experimental side, the $D\bar{D}^*K$ bound state could be found by analyzing the current world data of the $B \to J/\psi\pi\pi K$ process by focusing on the $J/\psi\pi K$ channel. Its confirmation could also help to understand the formation of kaonic nuclei in nuclear physics.

Parallel Session II / 14

On chiral extrapolations of charmed meson masses and coupled-channel reaction dynamics

Author(s): Dr. GUO, Xiao-Yu[1]
Co-author(s): Dr. HEO, Yonggoo [2] ; Prof. LUTZ, Matthias F. M. [3]

[1] *GSI Helmholzzentrum*

[2] *Suranaree University of Technology*

[3] *GSI Helmholzzentrum, Techinische Universität Darmstadt*

Corresponding Author(s): x.guo@gsi.de

We perform an analysis of QCD lattice data on charmed meson masses. The quark-mass dependence of the data set is used to gain information on the size of counter terms of the chiral Lagrangian formulated with open-charm states with $J^P = 0^-$ and $J^P = 1^-$ quantum numbers. Of particular interest are those counter terms that are active in the exotic flavour sextet channel. A chiral expansion scheme where physical masses enter the extrapolation formulae is developed and applied to the lattice data set. Good convergence properties are demonstrated and an accurate reproduction of the lattice data based on ensembles of PACS-CS, MILC, HPQCD, ETMC and HSC with pion and kaon masses smaller than 600 MeV is achieved. It is argued that a unique set of low-energy parameters is obtainable only if additional information from HSC on some scattering observables is included in our global fits. The elastic and inelastic s-wave πD and ηD scattering as considered by HSC is reproduced faithfully. Based on such low-energy parameters we predict 15 phase shifts and in-elasticities at physical quark masses but also for an additional HSC ensemble at smaller pion mass. In addition we find a clear signal for a member of the exotic flavour sextet states in the ηD channel, below the $\bar{K}D_s$ threshold. For the isospin violating strong decay width of the $D_{s0}(2317)$ we obtain the range $(45 - 49)$ keV.

Parallel Session II / 5

Measurement of the $D^{*+} - D^+$ mass difference

Prof. SOKOLOFF, Michael[1]

[1] *University of Cincinnati*

Corresponding Author(s): mike.sokoloff@uc.edu

We measure the mass difference, Δm_+, between the $D^*(2010)^+$ and the D^+, using the decay chain $D^*(2010)^+ \to D^+\pi^0$ with $D^+ \to K^-\pi^+\pi^+$. The data were recorded with the BaBar detector at center-of-mass energies at and near the $\Upsilon(4S)$ resonance, and correspond to an integrated luminosity of approximately 468 fb^{-1}. We measure $\Delta m_+ = (140\,601.0 \pm 6.8\,[\text{stat}] \pm 12.9\,[\text{syst}])$ keV. We combine this result with a previous BaBar measurement of $\Delta m_0 \equiv m(D^*(2010)^+) - m(D^0)$ to obtain $\Delta m_D = m(D^+) - m(D^0) = (4\,824.9 \pm 6.8\,[\text{stat}] \pm 12.9\,[\text{syst}])$ keV. These results are compatible with, and approximately five times more precise than, previous Particle Data Group averages.

Parallel Session II / 9

Mass spectra of triply heavy charm-beauty baryons

Author(s): Mrs. SHAH, Zalak[1]
Co-author(s): Dr. RAI, Ajaykumar [2]

[1] *Research Scholar*

[2] *SVNIT*

Corresponding Author(s): zalak.physics@gmail.com

We extract the mass spectra of triply heavy charm-beauty baryons using Hypercentral constituent quark model. The first order correction is also added to the potential term of Hamiltonian. The radial and orbital excited state masses are also determined. Moreover, the Regge trajectories and magnetic moments are also given for these baryons.

Parallel Session III / 23

Charm jet production and properties in pp, p-Pb, and Pb-Pb collisions measured with ALICE at the LHC

Mr. HASSAN, Hadi[1]

[1] *University Grenoble Alpes / LPSC Grenoble*

Corresponding Author(s): hadi.hassan@cern.ch

In Pb-Pb collisions at the LHC, a hot and dense medium of deconfined quarks and gluons is formed (Quark-Gluon Plasma, QGP).
The QGP is conjectured to be the state of matter of the early Universe up to few microseconds after the Big Bang and may still exist in the core of neutron stars. One of the most striking signatures of the QGP formation in heavy-ion collisions is the suppression of jet production. This phenomenon, called jet quenching, is ascribed to the energy lost by the initial parton while traveling through the QGP medium.
Heavy quarks lose energy via subsequent elastic scatterings with the medium constituents, and/or through gluon radiation. Theoretical models predict that energy loss depends on the color charge and mass of the hard-scattered parton traversing the medium. Such mass dependence can be studied by measuring the production of hadrons and jets containing heavy-quarks in pp, p-Pb and Pb-Pb collisions at the LHC.
In this contribution we will present the measurements of c-jet production in pp, p-Pb and Pb-Pb collisions performed with the ALICE detector at the LHC. The results obtained with pp and p-Pb data will be compared with predictions from event generators. Charm jets are tagged by requiring the presence of a D meson among its constituents. Thanks to the exclusive reconstruction of D-meson hadronic decay channels, the measurement of the jet-momentum fraction carried by the D meson is possible. This provides useful information to investigate charm fragmentation and production processes. The prospects for measuring b-jet production with ALICE will be also discussed.

Parallel Session III / 28

Status of radiative and rare leptonic tau decays at NLO

Dr. FAEL, Matteo[1]

[1] *University of Siegen*

Corresponding Author(s): fael@physik.uni-siegen.de

This talk will be a review of recent developments in the evaluation of NLO QED predictions for the radiative ($\tau \to l\gamma\nu\bar{\nu}$) and the rare ($\tau \to lll\nu\bar{\nu}$) tau decays, performed independently by two groups: Fael, Greub, Passera and Pruna, Signer, Ulrich. Fully differential NLO corrections are very important for the analysis of tau measurements aiming at the percent level or better, especially if very stringent phase-space cuts are applied.

Parallel Session III / 56

The inclusive reconstruction of Charmed mesons on B-factory

Dr. GZHYMKOVSKA, Olga[1]

[1] *INP PAS*

Corresponding Author(s): olgawerbycka@gmail.com

We will present inclusive method of the study of double charmed decays with strangeness $B \to \bar{D}^{(*)} D^{(*)}_{s(J)}$. The study based on the missing mass distributions in inclusive transitions $B \to \bar{D}^{(*)} X$, and thus in a way free from the assumptions about resonance decays $D^{(*)}_{s(J)}$. We will also present the perspective of such studies on next generation Belle II experiment.

Parallel Session III / 3

Study of radiative decays of the $\Upsilon(1S)$ and of three-body decays of the J/ψ

ANULLI, fabio[1]

[1] *INFN Sezione di Roma*

Corresponding Author(s): e.a.kozyrev@inp.nsk.su

We report on recent studies of quarkonium decays obtained with the data collected by the BaBar experiment at the PEP-II e^+e^- collider. In particular, we use the entire BaBar dataset to study the reaction $e^+e^- \to \gamma_{ISR} J/\psi$, with $J/\psi \to \pi^+\pi^-\pi^0$, $J/\psi \to K^+K^-\pi^0$, or $J/\psi \to K_S K^\pm\pi^\mp$, and the photon γ_{ISR} is produced via Initial-State-Radiation. We measure the relative J/ψ branching fractions and perform a Dalitz plot analysis of each J/ψ decay mode using an isobar model and a Veneziano model. We also present a study of the radiative decays of the $\Upsilon(1S)$ to $\pi^+\pi^-\gamma$ and $K^+K^-\gamma$ final states, performed on the data samples collected at the peak of the $\Upsilon(2S)$ and $\Upsilon(3S)$ resonances. The $\Upsilon(1S)$ is reconstructed from the decay chains $\Upsilon(nS) \to \pi^+\pi^-\Upsilon(1S)$, with $n = 2, 3$. Branching fractions measurements and spin-parity analyses are reported for the $\Upsilon(1S)$ radiative decays to intermediate resonances observed in the $\pi^+\pi^-$ and K^+K^- mass spectra.

Parallel Session III / 60

Measurements of the branching fractions of the J/ψ, $\psi(2S)$ decays to hadrons via ISR at BaBar

Prof. SOLODOV, Evgeny[1]

[1] *BINP*

Corresponding Author(s): e.p.solodov@inp.nsk.su

There are still less than 50% of the hadronic decays of J/ψ and $\psi(2S)$ known so far. We present an overview of the study of the J/ψ and $\psi(2S)$ production via ISR at BaBar. A few dozens of exclusive final states have been measured, many of them for the first time. Excellent detector performance allows to measure the major decay modes with low systematic errors. We present latest measurements of the J/ψ and $\psi(2S)$ branching fractions to the $\pi\pi\eta$, $K_SK_L\pi^0$, $K_SK_L\pi^0\pi^0$, and $KK_S\pi\pi^0$ modes.

Parallel Session III / 19

Measurements of charmed mesons and baryons in pp and p–Pb collisions with ALICE at the LHC

Mr. JAELANI, Syaefudin[1]

[1] *Utrecht University*

Corresponding Author(s): syaefudin.jaelani@cern.ch

Heavy quarks (charm and beauty) are produced in hard scattering processes at the early stage of the collision. Charmed-hadron production in small systems is important to test perturbative QCD calculations, to understand cold nuclear matter effects and to test possible collective effects. In addition their abundance is preserved during the subsequent collision stages making them effective probes for the hot and dense QCD medium (QGP) produced in heavy-ion collisions. The measurement of charmed-baryon production, and in particular of the charmed baryon-to-meson ratio (Λ_c^+/D^0), is sensitive to the charm hadronisation mechanism, which is a non-perturbative process. Moreover the measurements of heavier charmed baryons, for example Ξ_c^0, can be used to quantify the hadronisation of charm quarks into different hadron species. Furthermore, the measurements of charm hadrons in pp and p–Pb collisions constitute the necessary reference for measurements in Pb–Pb collisions.
In this talk, the recent measurements of open heavy flavours in pp and p–Pb collisions performed with the ALICE detector will be presented. These results include the p_T-differential production cross-section of non-strange D mesons (D^0, D^{*+} and D^+) and of the D_s^+ meson, and their nuclear modification factor in p–Pb collisions. We also present the recent measurements of the p_T-differential cross section of the Λ_c^+ baryon at mid-rapidity in pp collisions at $\sqrt{s} = 7$ TeV and in p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. In addition, the first measurement of Ξ_c^0–baryon production in the decay channel $\Xi_c^0 \to e^+\Xi^- {}^\circ{}_e$ in pp collisions at $\sqrt{s} = 7$ TeV at the LHC will be presented.

Parallel Session III / 42

Measurement of the Decay $\Lambda_c \to \Sigma\pi\pi$ at Belle

Mr. BERGER, Manfred[1] ; Dr. SCHWANDA, Christoph[2] ; Dr. SUZUKI, Ken[3]

[1] *Stefan-Meyer-Institute, Austrian Academy of Sciences*

[2] *Hephy, Austrian Academy of Sciences*

[3] *Stefan-Meyer-Institute*

Corresponding Author(s): manfred.berger@oeaw.ac.at

Recent model-independent measurements of the absolute branching ratio of the normalization mode $\Lambda_c- > p^+K^-\pi^+$ by the Belle[1] and BES3[2] collaborations have significantly increased the precision of previously measured decay channels. BES3 also independently updated the value for the $\Lambda_c^+ \to \Sigma^+\pi^-\pi^+$ mode, however the branching fraction into the $\Lambda_c^+ \to \Sigma^0\pi^0\pi^+$ decay channel has not been improved upon since the measurement by the CLEO[3] collaboration.
We report new measurements of the branching fractions of the decays $\Lambda_c^+ \to \Sigma^+\pi^-\pi^+$, $\Sigma^0\pi^0\pi^+$ and $\Sigma^+\pi^0\pi^0$ based on 711 fb^{-1} of integrated luminosity recorded with the Belle detector at the KEKB asymmetric energy e^+e^- collider near the $\Upsilon(4S)$ resonance (charge conjugated decays are implicitly included). All results are obtained relative to $\Lambda_c^+ \to pK^-\pi^+$. This is the

first measurement of the $\Lambda_c^+ -> \Sigma^+\pi^0\pi^0$ channel. The measurements of the other modes are significantly more precise compared to previous analyses and of similar precision to the recent BES3 results.

1 A. Heller et al. (Belle Collaboration) Phys. Rev. D 91, 112009 (2014)
2 M. Ablikim et al. (BESIII Collaboration) Phys. Rev. Lett. 116, 052001 (2015)
3 P. Avery et al. (CLEO Collaboration) Physics Letters B, Volume 325, Issue 1 (1994)

Parallel Session IV / 27

Heavy quark expansion for inclusive charm decays

Dr. FAEL, Matteo[1]

[1] *University of Siegen*

Corresponding Author(s): fael@physik.uni-siegen.de

The heavy mass expansion (HME) has been an indispensable tool for precision calculation in flavor physics, especially for bottom hadrons. However, there have been always doubt if the HME is applicable to charm decays with the same success since both $\alpha_s(m_c)$ and $\Lambda_{\rm QCD}/m_c$ are not very small parameters.
However one can turn the vice into a virtue. Since $\Lambda_{\rm QCD}/m_c$ is not that small, there is a larger sensitivity to higher order terms of the HME in charm decays compared to bottom decays. To this end, inclusive semileptonic charm decays may serve as a tool to study the anatomy of the subleading terms of the HME.
In this talk I will report about some recent developments in the evaluation of the $\Lambda^3_{\rm QCD}/m_c^3$ and $\Lambda^4_{\rm QCD}/m_c^4$ terms for semileptonic charm decays. For the charm, the appropriate expansion is a double seires in powers of m_s/m_c as well as in $\Lambda_{\rm QCD}/m_c$. The expansion is not just a trivial tailor series of the results for the $b \to c$ transition but it contains also non analytic terms due to the infrared sensitivity to the strange mass emerging at higher order.

Parallel Session IV / 0

Decay $D_s \to \phi\ell^+\nu_\ell$ in covariant quark model

Mr. SONI, Nakul[1] ; PANDYA, J. N.[1]

[1] *Applied Physics Department, The Maharaja Sayajirao University of Baroda, Vadodara*

Corresponding Author(s): nrsoni-apphy@msubaroda.ac.in

The semileptonic charmed meson decays are the ideal tools to explore the various aspects of heavy quark decays. We study the leptonic and semileptonic D_s meson decays ($D_s \to \ell^+\nu_\ell$ and $D_s \to \phi\ell^+\nu_\ell$) in the framework of covariant quark model (CQM) with built-in infrared confinement. The CQM is an effective quantum field approach for the hadronic interaction based on effective Lagrangian of hadrons interacting with the constituent quarks. The required form factors are computed in the entire range of momentum transfer and used to determine semileptonic branching fractions. The computed branching fractions are in close resemblance with the recent BESIII data [arXiv:1709.03680] and other experimental results.

Parallel Session IV / 4

CP violation in charm decays into neutral kaons

Dr. YU, Fu-Sheng[1]

[1] *Lanzhou University*

Corresponding Author(s): yufsh@lzu.edu.cn

We find a new CP-violation effect in charm decays into neutral kaons, which results from the interference between two tree (Cabibbo-favored and doubly Cabibbo-suppressed) amplitudes with

the mixing of final-state mesons. This effect, estimated to be of order of 10^{-3}, is much larger than the direct CP asymmetries in these decays, but missed in the literature. It can be revealed by measuring the difference of the time-dependent CP asymmetries in the $D^+ \to \pi^+ K^0_S$ and $D^+_s \to K^+ K^0_S$ modes, which are accessible at the LHCb and Belle II. If confirmed, the new effect has to be taken into account, as the above direct CP asymmetries are used to search for new physics.

Parallel Session IV / 7

Sequential Coalescence with Charm Conservation in Heavy Ion Collisions

Author(s): Mr. ZHAO, Jiaxing[1]
Co-author(s): Prof. NU, Xu [2] ; Mr. SHI, Shuzhe [3] ; Prof. ZHUANG, Pengfei [1]

[1] *Tsinghua University*

[2] *CCNU*

[3] *Indiana University*

Corresponding Author(s): zhao-jx15@mails.tsinghua.edu.cn

Heavy quarks are only initially produced in nuclear collisions and the number is conserved during the evolution of the system. We determine the sequence of charmed hadron production by solving a relativistic potential model and hydrodynamic equations. By embedding the charm conservation in a sequential coalescence model, the later produced charmed hadrons are suppressed. Combining together with the strangeness enhancement, the charm conservation e[U+FB00]ect is signi[U+FB01]cantly enlarged in yield ratios involving charm-strange hadrons like Ds/D0 in heavy ion collisions.

Parallel Session IV / 38

Parametrizations of three-body hadronic B- and D-decay amplitudes

Dr. LOISEAU, Benoit[1]

[1] *LPNHE (Paris, FRANCE)*

Corresponding Author(s): loiseau@lpnhe.in2p3.fr

On behalf of my colleagues, I will present a short review on our recent work [1] on parametrizations of weak B and D decays into final states composed of three light mesons, namely the various charge states $\pi\pi\pi$, $K\pi\pi$ and $KK\bar{K}$. These parametrizations are derived from previous calculations based on a quasi-two-body factorization approach in which two-body hadronic final state interactions are fully taken into account in terms of unitary S- and P-wave $\pi\pi$, πK and $K\bar{K}$ form factors. They are an alternative to the isobar-model Dalitz-plot parametrizations and can be useful in the interpretation of CP asymmetries.
[1] D. Boito, J.-P. Dedonder, B. El-Bennich, R. Escribano, R. Kaminski, L. Lesniak, and B. Loiseau, Parametrizations of three-body hadronic B- and D-decay amplitudes in terms of analytic and unitary meson-meson form factors, Phys. Rev. D 96, 113003 (2017).

Parallel Session IV / 10

Amplitude analysis of multiparticle decay reactions

Dr. MIKHASENKO, Mikhail[1]

[1] *HISKP, Universität Bonn*

Corresponding Author(s): mikhail.mikhasenko@gmail.com

The nature of the recently discovered exotic charmonium-like states is still an open question. The distinction between different underlying physical pictures often relies on an analysis of the resonance lineshape. In this context, it becomes crucial to know how exactly the amplitude should incorporate resonances and what uncertainties we expect from the formalism.
In the talk, I will discuss the construction of the reaction amplitude for the decay B -> Psi pi K, where the exotic Z(4430) signal was observed. Two commonly-used recipes (the tensor formalism and the helicity formalism) provide frameworks to construct the partial-wave amplitude but do not lead to the same answer. I will demonstrate and clarify the differences between these frameworks as well as their impact on the lineshapes. The approach based on analyticity and crossing symmetry which allows minimizing model dependence will be presented.

Parallel Session IV / 18

A new parametrization for the scalar isoscalar pion form factor

Author(s): Mr. ROPERTZ, Stefan[1]
Co-author(s): Dr. HANHART, Christoph [2] ; Dr. KUBIS, Bastian [1]

[1] *University of Bonn*

[2] *Forschungszentrum Jülich Institute for Nuclear Physics*

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

Dispersion theory is a powerful tool for partial wave analyses of decay and scattering processes involving light mesons. However, as a result of the onset of various inelastic channels, its simple single- or two-channel implementations can in practice be applied only up to energies of about 1.1 GeV. In this talk we introduce an effective parametrization for the isoscalar, scalar pion form factor which preserves the principles of analyticity and unitarity. Furthermore it allows us to introduce higher resonances and inelastic channels and at the same time matches smoothly on the dispersive representation at low energies. We show how it can be applied to decays $\bar{B}_s^0 \to J/\psi\,\pi^+\pi^-(K^+K^-)$ measured by LHCb. Since the parametrization is analytic it allows us to explore the structure of the form factor in the complex plane giving rise to resonance poles. In order to extract those we use the model-independent and easily applicable approach of Pad\'e approximants.

Production of Charm and Charmonia / 86

Multiple charm(onium) production at LHC

Corresponding Author(s): Semen.Turchikhin@cern.ch

Production of Charm and Charmonia / 87

Soft gluon factorization

Corresponding Author(s): yqma@pku.edu.cn

Production of Charm and Charmonia / 84

Open charm production at LHC

Corresponding Author(s): sergey.barsuk@cern.ch

Production of Charm and Charmonia / 85

Charmonium production at LHC (prompt and from B decays)

Corresponding Author(s): xiaorui@ucas.ac.cn

Production of Charm and Charmonia / 37

Double charmonia production in the LHC

Author(s): Dr. POSLAVSKY, Stanislav[1]
Co-author(s): Prof. LIKHODED, Anatolii [2] ; Dr. LUCHINSKY, Alexey [2]

[1] *Institute for High Energy Physics NRC "Kurchatov Institute"*

[2] *Institute For High Energy Physics NRC "Kurchatov Institute"*

Corresponding Author(s): stvlpos@mail.ru

In this talk I'll give a brief overview of the recent theoretical results on paired charmonia production in the LHC. Special attention will be payed to the problem of parton shower formation, namely to the problem how one can discriminate between single parton scattering and double parton scattering, and how these different mechanisms manifests in the picture of multiple heavy quarkonia production.

Production of Charm and Charmonia / 36

Review of Heavy Quarkonium Production

Dr. ZHANG, Hong-Fei[1]

[1] *TBD*

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

Many important progresses in heavy quarkonium physics have been made in recent years. This talk wants to provide a state-of-the-art introduction to both the theoretical and phenomenological progresses in heavy quarkonium production, including the newly proposed Soft Gluon Factorization (SGF), and Improved Color Evaporation Model (ICEM), and the phenomenological studies in NRQCD.

Tau lepton Physics / 55

Hadronic decays of the tau lepton

Prof. LUSIANI, Alberto[1]

[1] *Scuola Normale Superiore*

Corresponding Author(s): alberto.lusiani@pi.infn.it

We review the status of the experimental measurements of tau decays and the tau structure functions and the status and prospects of their elaborations to extract the strong coupling constant, to compute the hadronic contribution to the muon anomaly and to measure the CKM matrix coefficient V_{us}.

Tau lepton Physics / 34

Low-energy tests of QCD with tau decay data

Prof. PICH, Antonio[1]

[1] *IFIC, U. Valencia - CSIC*

Corresponding Author(s): antonio.pich@uv.es

Using the most recent release of the ALEPH decay data, we report several relevant tests of perturbative and non-perturbative aspects of QCD. We present the most recent determination of the strong coupling constant, from an exhaustive phenomenological analysis that exploited the sensitivity to the QCD coupling in many different ways. Through the study of the left-right two-point correlation function, several order parameters of the QCD chiral symmetry breaking are determined. Implications for the Standard Model prediction of the kaon direct-CP-violating parameter $'/$ will also be briefly discussed.

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Welcome by Prof. Pavel Logachev

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Probing of strong interactions and hadron matter with charmonium-like studies

Author(s): Dr. BARABANOV, Mikhail[1]
Co-author(s): Prof. OLSEN, Stephen [2] ; Prof. VODOPYANOV, Alexander [1]

[1] *JINR*

[2] *UCAS*

Corresponding Author(s): barabanov@jinr.ru

The spectroscopy of charmonium-like mesons with masses above the $D\bar{D}$ threshold has been full of surprises and remains poorly understood [1]. The currently most compelling theoretical descriptions of the mysterious XYZ mesons attributes them to higher lying charmonium states [2], hybrid structure with a tightly bound $c\bar{c}$ diquark [3, 4] or a $cq(\bar{cq'})$ tetraquark [3, 5] core that strongly couples to S-wave $D\bar{D}$ molecule-like structures. In this picture, the production of a XYZ particle in high energy hadron collisions and its decays into light hadron plus charmonum final states proceed via the core component of the meson, while decays to pairs of open charmed mesons proceed via the $D\bar{D}$ component. Until now charmonium-like spectroscopy represents 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 [6 - 8]. The experiments with antiproton-proton annihilation and proton-nuclear collisions are well suited for a comprehensive spectroscopy program, in particular, the spectroscopy of charmonium-like exotic states. These states can be produced abundantly in both processes, and their properties can be studied in detail [6 - 8]. For this purpose an elaborated analysis of main characteristics of charmonium-like spectrum is given. The recent experimental data from different collaborations (BES, BaBar, Belle, LHCb) are analyzed. A special attention was given to the XYZ-particles. The attempts of their possible interpretation are considered [2, 3, 9, 10]. The results of physics simulations for decays into light hadrons plus charmonium in final state and open charmed mesons 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 earlier by Maiani and Polosa [11]. But much more data on different decay modes are needed before firmer conclusions can be made. These data can be derived from the experiments using a high quality antiproton beam with momentum up to 15 GeV/c and proton-nuclear collisions with momentum up to 26 GeV/c.
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Particle Identification at the PANDA/FAIR experiment using DIRC and RICH detectors

Dr. HAYRAPETYAN, Avetik[1]

[1] *II Phys. Inst. JLU Giessen*

Corresponding Author(s): avetik.hayrapetyan@uni-giessen.de

The PANDA experiment at the new FAIR facility in Darmstadt/Germany will cover a broad range of hadron physics, using an antiproton beam with a momentum of 1.5 – 15 GeV/c colliding on a fixed hydrogen or a nuclear target. The reactions will be registered by the combination of a hermetic target spectrometer and a forward spectrometer. Of a special importance is an excellent charged particle identification (e,mu,π,K,p). In order to achieve that in a broad angular and momentum range, three different imaging Cherenkov detectors will be installed. The very forward region (0°-10°) will be covered by the Forward RICH subdetector employing a focusing multilayer aerogel radiator, while the larger angles are served by two DIRC subdetectors based on fused silica radiators in combination with special focusing optics: Endcap Disc DIRC (5°-22°) and Barrel DIRC (22°-140°).
The design and specification of the proposed Cherenkov detectors and results from beam tests with prototypes will be presented.

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A measuring systems of the wires resonant frequency for Drift Chamber

Mr. CHIARELLO, Gianluigi[1] ; Dr. TASSIELLI, Giovanni Francesco[2] ; Dr. GRANCAGNOLO, Francesco[3] ; Mrs. MICCOLI, Alessandro[1]

[1] *INFN Lecce*

[2] *INFN Lecce & University of Salento*

[3] *INFN*

Corresponding Author(s): alessandro.miccoli@le.infn.it

The ultra-low mass Drift Chamber designed for the MEG experiment upgrade (MEG-II) is a challenging apparatus made of 1920 20μm Au plated W sense wires, 2304 50μm and 7680 40μm Ag plated Al field wires. For logistic motivations, the chamber construction is made in three stages: the wires are first simultaneous wired in multi-wire layers, then the wire layers are extracted from the wiring robot and placed in a storage and transport frame. Lastly, they are mounted on the chamber end plate supports. Electrostatic stability considerations and the total length of the chamber, ˜2m, require that all the different wires be stretched at mechanical tensions respectively of about 25g, 29g, 19g and controlled at a level better than 0.5g. Since the mounting procedure is divided in three steps, it is necessary to check the mechanical tension of the wires during the different phases and, in particular, before and after the closing of the chamber. To fulfill this goal we have developed a measuring system to determine the wires first harmonic resonant frequency. The system force the wires oscillation by applying a sinusoidal HV (˜1000V) signal at a known frequency, and then it measures the variation of the mutual capacitance between two adjacent wires as function of the HV signal frequency. We present the details of a measuring system and the results obtained by scanning the wires mechanical tensions of the MEG-II Drift Chamber.

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The automatic system for the construction of Drift Chambers for modern High Energy Physics experiments

Mr. CHIARELLO, Gianluigi[1] ; Dr. TASSIELLI, Giovanni Francesco[2] ; Dr. GRANCAGNOLO, Francesco[3] ; Mr. MICCOLI, Alessandro[1]

[1] *INFN Lecce*

[2] *INFN Lecce & University of Salento*

[3] *INFN*

Corresponding Author(s): alessandro.miccoli@le.infn.it

Modern experiments for the search of extremely rare processes require high momentum resolutions (order of 50-100 keV/c) tracking systems for particle momenta in the range of 50-100 MeV/c, dominated by multiple scattering contributions. A typical tracking detector with high precision and ability to withstand high rates is a full stereo, high granularity Drift Chamber. Due their high wire density and the stringent requirements on spatial resolution, the use of the classical feed-through technique as wire anchoring system can hardly be implemented and therefore it is necessary to develop an automatic system (wiring robot) with a highly performing control and monitoring system that synchronizes the different operation. The wiring robot has been designed for managing a large number of densely spaced wires; for monitoring the solder quality of the wire to the supporting Printed Circuit Boards; for applying the wires mechanical tension and maintaining it constant and uniform through the entire chamber; for monitoring the wire positions and their alignments within a few tens μm. The wiring robot consists of:\\

- **WIRING SYSTEM:** a semiautomatic wiring machine with a high precision on wire mechanical tensioning (<0.1g) and on wire positioning (<20μm) for a simultaneous wiring of multiwire layers;
- **SOLDERING SYSTEM:** a contact-less infrared laser soldering tool for anchoring the wires to the supporting PCB;
- **EXTRACTION SYSTEM:** an automatic handling system for storing and transporting the multi-wire layers at adjustable wire tension.

All subsystems of the wiring robot are managed and synchronized with a real-time system, based on a National Instrument CompactRIO platform. The wiring robot was used for the construction of MEG II Drift Chamber.

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The full stereo Drift Chamber of the MEGII experiment

Dr. GRANCAGNOLO, Francesco[1] ; Dr. TASSIELLI, Giovanni Francesco[2] ; Mr. CHIARELLO, Gianluigi[3] ; Mr. MICCOLI, Alessandro[3]

[1] *INFN*

[2] *INFN Lecce & University of Salento*

[3] *INFN Lecce*

Corresponding Author(s): alessandro.miccoli@le.infn.it

The aim of MEG experiment is looking for the $\mu^+ \to e^+\gamma$ at the Paul Scherrer Institute (PSI). The decay $\mu^+ \to e^+\gamma$ is an extremely rare process of the violation of the flavour of charged-leptons and it is forbidden in the Model Standard that foresees an experimentally unattainable branching ratio$BR \approx 10^{-55}$. The new positron tracker is a high transparency single volume, full stereo cylindrical Drift Chamber (CDCH), filled with a gas mixture of helium-isobutane. The MEG tracker is immersed in a non uniform longitudinal B-field, co-axial to the muon beam line with length of 1.93 m, internal radius of 17 cm and external radius of 30 cm. It is composed of 10 concentric layers, divided in 12 identical sector, each layer consisting of a sense wires plane between two field wires planes at alternating signs stereo angles ranging from 6 deg to 8 deg for a improve reconstruction of the longitudinal coordinate. Each layer is composed of 192 drift cells (16 for sector), the single drift cell is approximately square, with a 20 μm gold plated W sense wire surrounded by 40 μm silver plated Al field wires in a ratio of 5:1. For equalizing the gain of the innermost and outermost layers, two guard layers have been added at proper radii and at appropriate high voltages. The total number of wires amounts to 12288 for an equivalent

radiation length per track turn of about 1.45x10^{-3} X_0 when the chamber is filled with gas mixture of helium and isobutane in the ratio 85:15. Due to the high wire density ($12 wires/cm^2$), the use of the classical feed-through technique as wire anchoring system could hardly be implemented and therefore it was necessary to develop new wiring strategies. The number of wires and the stringent requirements on the precision of their position and on the uniformity of the wire mechanical tension impose the use of an automatic system (wiring robot) to operate the wiring procedures. \\ Several tests have been performed in different prototypes of the drift chamber, exposed to cosmic rays, test beams and radioactive sources, to fulfill the requirement on the spatial resolution to be less than 110 μm. Since the longitudinal coordinate of hits is determined by exploiting the stereo angle, the corresponding resolution is then expected to be $\sigma_z \simeq 1\ mm$. However in the final chamber further improvements are expected due to the new front-end electronics allowing for the exploitation of the cluster timing technique.

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Improving spatial and PID performance of the high transparency Drift Chamber by using the Cluster Counting and Timing techniques

Mr. CHIARELLO, Gianluigi[1] ; Dr. TASSIELLI, Giovanni Francesco[2] ; Dr. GRANCAGNOLO, Francesco[3] ; Mr. MICCOLI, Alessandro[1]

[1] *INFN Lecce*

[2] *INFN Lecce & University of Salento*

[3] *INFN*

Corresponding Author(s): alessandro.miccoli@le.infn.it

Helium based ultra-low mass and high granularity Drift Chambers are an optimal solution as tracking systems of modern High Energy Physics experiments, both for the search of extremely rare processes (MEG-II), where the momentum and angular resolutions are dominated by multiple scattering contributions, and for experiments at future high luminosity e+e- colliders (FCC/CEPC), where, in addition to excellent tracking performance, PID capabilities have great impact. We present how, in Helium based gas mixtures, by counting and measuring the arrival times of each individual ionization cluster and by using statistical tools, it is possible to have a bias free estimate of the impact parameter, therefore, an improved momentum and angular resolutions and a more discriminant PID with the dN/dx technique, as opposed to the traditional dE/dx truncated method. We'll illustrate the expected performance with detailed simulations and with experimental results for some particular energy. The use of a high gain, high bandwidth (˜1 GHz) front-end amplifier and of a high sampling rate FADC (˜2GS/s) are required to successfully applying the Cluster Counting/Timing technique. The integration of a full front-end chain, based on a 12bit FADC, and an acquisition system, based on a suitably programmed FPGA to process online the drift chamber signals, in order to extract efficiently only the relevant cluster information, will be discussed. Details of the fast algorithm used to reduce, in a sizeable way, the data throughput, a crucial aspect to make the Cluster Counting/Timing technique usable in a full scale detector, will be illustrated.

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Charm Quark Mass with Calibrated Uncertainty

Author(s): Prof. ERLER, Jens[1]
Co-author(s): Prof. SPIESBERGER, Hubert [2] ; Dr. MASJUAN, Pere [3]

[1] *IF-UNAM (Mexico City)*

[2] *MITP Mainz*

[3] *IFAE Barcelona*

Corresponding Author(s): erler@fisica.unam.mx

We determine the charm quark mass mc(mc) from QCD sum rules of moments of the vector current correlator calculated in perturbative QCD. Only experimental data for the charm resonances below the continuum threshold are needed in our approach, while the continuum contribution

is determined by requiring self-consistency between various sum rules, including the one for the zeroth moment. Existing data from the continuum region can then be used to bound the theoretical error. Our result is mc(mc)=1272±8 MeV for αs(MZ)=0.1182. Special attention is given to the question how to quantify and justify the uncertainty.