

# **Conference on Flavour Physics and CP violation (FPCP) 2020**

Monday 8 June 2020 - Friday 12 June 2020

## **Book of Abstracts**



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## **Lunch**

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## **|V<sub>ib</sub>| measurements in SL b decays**

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**Neutrinos / 60**

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## **Experimental status on neutrinoless double-beta decays**

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## **Sterile neutrinos**

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**Flavour production / 65**

## **Theoretical status of flavour production at hadron colliders**

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**Hadronic charm meson decays at BESIII****Author:** Jingzhi Zhang<sup>1</sup><sup>1</sup> *IHEP***Corresponding Author:** jingzhi@ihep.ac.cn

BESIII has collected data samples corresponding to luminosities of 2.93 fb<sup>-1</sup> and 3.19 fb<sup>-1</sup> at center-of-mass energies of 3.773 and 4.178 GeV, respectively. The data set collected at 3.773 GeV contains quantum-correlated D<sup>0</sup>D<sup>0</sup> $\bar{0}$  pairs that allow access to the phase differences between amplitudes. We report the measurements of strong phase differences in D<sup>0</sup> decays, including KS/L pi<sup>+</sup> pi<sup>-</sup>, which can reduce the gamma/phi<sup>3</sup> measurement systematic uncertainty at LHCb and Belle II. In addition, we report the measurements of the absolute branching fractions and the amplitude analyses of D<sup>+</sup>, D<sup>0</sup>, and D<sub>s</sub> decays.

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**Light meson decays at BESIII****Author:** Jingzhi Zhang<sup>1</sup><sup>1</sup> *IHEP***Corresponding Author:** jingzhi@ihep.ac.cn

Due to the high production rate of light mesons in J/psi decays, the high statistics sample of 1.3 billion Jpsi events provide an ideal lab to investigate the decay dynamics of light mesons, in particular for eta and eta prime. Recently the BESIII experiment made significant progresses in eta and prime decays, including their hadronic and rare decays, which will be reported in this talk

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**XYZ at BESIII****Author:** Jingzhi Zhang<sup>1</sup><sup>1</sup> *IHEP***Corresponding Author:** jingzhi@ihep.ac.cn

From 2011, BESIII has taken about 20 fb<sup>-1</sup> data samples at center of mass energies from 3.8 to 4.6 GeV, containing 21 energy points with luminosity larger than 400 pb<sup>-1</sup>. This makes the study of vector states Y, charged states Z, X states, as well as the connections between them through transition processes possible. Using these data samples, new information about X(3872) decays, Y

states from open-charm final states, hidden-charm final states, and light hadron final states will be presented.

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## PROBING OF MULTIQUARKS STRUCTURE IN HADRON AND HEAVY ION COLLISIONS

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The spectroscopy of charmonium-like mesons with masses above the  $2m_D$  open charm threshold has been full of surprises and remains poorly understood [1]. The currently most compelling theoretical descriptions of the mysterious XYZ mesons attribute them to hybrid structure with a tightly bound  $c\bar{c}$  diquark [2] or  $cq(c\bar{q})$  tetraquark core [3 - 5] that strongly couples to S-wave  $D\bar{D}$  molecular like structures. In this picture, the production of a XYZ states in high energy hadron collisions and its decays into light hadron plus charmonium 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. These ideas have been applied with some success to the XYZ states [2], where a detailed calculation finds a  $c\bar{c}$  core component that is only above 5% of the time with the  $D\bar{D}$  component (mostly  $D_0\bar{D}_0$ ) accounting for the rest. In this picture these states are composed of three rather disparate components: a small charmonium-like  $c\bar{c}$  core with  $r_{rms} < 1$  fm, a larger  $D+D^-$  component with  $r_{rms} = \hbar/(2\mu+B)^{1/2} \approx 1.5$  fm and a dominant component  $D_0\bar{D}_0$  with a huge,  $r_{rms} = \hbar/(2\mu_0B_0)^{1/2} > 9$  fm spatial extent. Here  $\mu+(\mu_0)$  and  $B+(B_0)$  denote the reduced mass for the  $D+D^-$  ( $D_0\bar{D}_0$ ) system and the relevant binding energy  $|m_D + m_{\bar{D}} - M_{X(3872)}|$  ( $B_+ = 8.2$  MeV,  $B_0 < 0.3$  MeV). The different amplitudes and spatial distributions of the  $D+D^-$  and  $D_0\bar{D}_0$  components ensure that the  $X(3872)$  is not an isospin eigenstate. Instead it is mostly  $I = 0$ , but has a significant ( $\sim 25\%$ )  $I = 1$  component.

In the hybrid scheme, XYZ mesons are produced in high energy proton-nuclei collisions via its compact ( $r_{rms} < 1$  fm) charmonium-like structure and this rapidity mixes in a time ( $t \sim \hbar/\delta M$ ) into a huge and fragile, mostly  $D_0\bar{D}_0$ , molecular-like structure.  $\delta M$  is the difference between the XYZ meson mass and that of the nearest  $c\bar{c}$  mass pole core state, which we take to be that of the  $\chi_{c1}(2P)$  pure charmonium state which is expected to lie about  $20 \sim 30$  MeV above  $M_{X(3872)}$  [6, 7]. In this case, the mixing time,  $c\tau_{mix} \sim 5 \sim 10$  fm, is much shorter than the lifetime of  $X(3872)$  which is  $c\tau_{X(3872)} > 150$  fm [8].

The experiments with proton-proton and proton-nuclei collisions with  $\sqrt{s_{pN}}$  up to 26 GeV and luminosity up to  $10^{32} \text{ cm}^{-2}\text{s}^{-1}$  planned at NICA are well suited to test this picture for the  $X(3872)$  and other XYZ mesons. In near threshold production experiments in the  $\sqrt{s_{pN}} \approx 8$  GeV energy range, XYZ mesons can be produced with typical kinetic energies of a few hundred MeV (i.e. with  $\gamma\beta \approx 0.3$ ). In the case of  $X(3872)$ , its decay length will be greater than 50 fm while the distance scale for the  $c\bar{c} \rightarrow D_0\bar{D}_0$  transition would be  $2 \sim 3$  fm. Since the survival probability of an  $r_{rms} \sim 9$  fm "molecular" inside nuclear matter should be very small, XYZ meson production on a nuclear target with  $r_{rms} \sim 5$  fm or more ( $A \sim 60$  or larger) should be strongly quenched. Thus, if the hybrid picture is correct, the atomic number dependence of XYZ production at fixed  $\sqrt{s_{pN}}$  should have a dramatically different behavior than that of the  $\psi'$ , which is long lived compact charmonium state. The current experimental status of XYZ mesons together with hidden charm tetraquark candidates and present simulations what we might expect from A-dependence of XYZ mesons in proton-proton and proton-nuclei collisions are summarized.

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## **Latest results in neutron EDM at PSI**

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## **Probing NP in four-fermion interactions with dipole processes**

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Four-fermion effective interactions have played a major role in the formulation of the Standard Model (SM) of particle physics. Nowadays, they are of fundamental importance in establishing the viability of extensions of the SM, since this category of operators is sensitive to the flavor structure of New Physics (NP), including new sources of CP violation. Following the renormalization of four-fermion operators, they mix into dipole operators, thus inducing powerful constraints on their effective coupling constants (i.e., their Wilson coefficients). For many four-fermion operators, such mixing is absent at one-loop. Here, I would like to present the calculation of their leading-order two-loop mixing into dipoles, and the resulting phenomenological bounds on generic NP models that generate four-fermion effective interactions at energies much above the ElectroWeak scale.

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## **Recent results from charged-current semileptonic B decays at LHCb**

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Recent results from semileptonic b $\rightarrow$ clnu and b $\rightarrow$ ulnu decays studied at 7 TeV, 8 TeV and 13 TeV centre-of-mass energy with the LHCb detector will be reported. These include the measurement of hadronic form-factors in the Bs $\rightarrow$ Ds\* $\mu\nu$  decay and the first observation of the B $\rightarrow$ ppbarmunu decay.

**Flavour production / 85**

## **Enhanced production of multi-strange hadrons in high-multiplicity proton-proton collisions**

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## Recent Searches for Hidden-Sector Particles with BABAR

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Many models of dark matter and hidden sectors predict new particles with masses below the electroweak scale. Low-energy electron-positron colliders such as BABAR are ideally suited to discover these hidden-sector particles. We present several recent BABAR searches for low-mass hidden-sector particles, including new searches for prompt and long-lived leptonically decaying hidden scalars produced in association with tau leptons. This search is sensitive to viable models that could account for the muon  $g - 2$  excess. We also present results a search for dark muonic forces, and for invisible particles produced in six-quark final states. These examples show the importance of B-factories in constraining and discovering new hidden-sector physics beyond the Standard Model.

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## Rare and forbidden decays of $D^0$ meson.

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We report the observation of the rare charm decay  $D^0 \rightarrow K^- \pi^+ e^+ e^-$ , a search for nine lepton-number-violating and three lepton-flavor-violating neutral charm decays of the type  $D^0 \rightarrow h^- h'^+ \ell^+ \ell'^+$ , and  $D^0 \rightarrow h^- h'^+ \ell^+ \ell'^-$ , and a search for seven lepton-number-violating decays of the type  $D^0 \rightarrow X^0 e^\pm \mu^\mp$ , where  $h$  and  $h'$  represent a  $K$  or  $\pi$  meson,  $\ell$  and  $\ell'$  an electron or muon, and  $X^0$  a  $\pi^0$ ,  $K_S^0$ ,  $K^{*0}$ ,  $\rho^0$ ,  $\phi$ ,  $\omega$ , or  $\eta$  meson. The results are based on  $468 \text{ fb}^{-1}$  of  $e^+e^-$  collision data collected at or close to the  $\Upsilon(4S)$  resonance with the BaBar detector at the SLAC National Accelerator Laboratory.

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## $\tau - \mu$ lepton flavor universality in $\Upsilon(3S)$ decays at the BABAR experiment

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We report on a precision measurement of the ratio  $R_{\tau\mu} = BF(\Upsilon(3S) \rightarrow \tau^+ \tau^-) / BF(\Upsilon(3S) \rightarrow \mu^+ \mu^-)$  using data collected with the BABAR detector at the SLAC PEP-II  $e^+e^-$  collider. The measurement is based on a  $28 \text{ fb}^{-1}$  data sample collected at a center-of-mass energy of  $10.355 \text{ GeV}/c^2$  which corresponds to a sample 122 million  $\Upsilon(3S)$  mesons. In order to estimate backgrounds from direct dilepton production we use  $2.6 \text{ fb}^{-1}$  of data collected 30 MeV below the  $\Upsilon(3S)$  resonance mass and  $86 \text{ fb}^{-1}$  of data collected near the  $\Upsilon(4S)$  resonance. The ratio is measured to  $R_{\tau\mu} = 0.9662 \pm 0.0084 \pm 0.0135$  and is in agreement with the Standard Model prediction. Its uncertainty

is almost order of magnitude smaller than the only previous measurement reported by the CLEO collaboration.

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## Study of resonant-states production in $e^+e^-$ annihilation in the energy region around 2.2 GeV

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Two vector resonances with a mass near 2.2 GeV/ $c^2$  are presently known: the  $\phi(2170)$  observed in several production processes, but seen to decay only to  $\phi(2170) \rightarrow \phi(1020)f_0(980)$ , and the not well established  $\rho(2150)$ . Recently the BES-III experiment observed a clear interference pattern in the same energy region in  $e^+e^- \rightarrow K^+K^-$ , interpreted as a resonance with a mass of 2239 GeV and a width of 0.14 GeV. To shed light on the resonant states in this energy region we measure the reaction  $e^+e^- \rightarrow K_S K_L$  with data collected with the *BABAR* detector, and analyse these data in conjunction with published BES-III data on  $e^+e^- \rightarrow K^+K^-$  and *BABAR* data on  $e^+e^- \rightarrow K^+K^-$ ,  $\pi^+\pi^-$ ,  $\pi^+\pi^-\eta$ ,  $\pi^+\pi^-\omega$ . This study supports the existence of an isovector resonance  $\rho(2230)$  with mass  $M = 2232 \pm 8 \pm 9$  MeV/ $c^2$  and width  $\Gamma = 133 \pm 14 \pm 4$  MeV/ $c^2$ , consistent with the resonance observed by BES-III.

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## SEARCH FOR EXOTIC DECAYS WITH NA62

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The NA62 experiment at the CERN SPS is designed to measure the branching ratio of the  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  decay, one of the best candidates to reveal indirect effects of new physics at the highest mass scales. NA62 took data in 2016-2018. The high-intensity fixed-target setup and detector performance make the NA62 experiment particularly suited for searches of new physics from faintly interacting particles in the MeV–GeV mass range: heavy-neutral leptons, axion-like particles, and others. The results from the analysis of data taken with dedicated setup and triggers developed to this purpose will be highlighted.

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## The search for proton and deuteron Electric Dipole Moments using storage rings

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The Standard Model (SM) of Particle Physics is not capable to account for the apparent matter-antimatter asymmetry of our Universe. Physics beyond the SM is required and is either probed by employing highest energies (e.g., at LHC), or by striving for ultimate precision and sensitivity (e.g., in the search for electric dipole moments). Permanent electric dipole moments (EDMs) of particles violate both time reversal (T) and parity (P) invariance, and are via the CPT-theorem also CP-violating. Finding a non-zero EDM would be a strong indication for physics beyond the SM, and pushing upper limits further provides crucial tests for any corresponding theoretical model. Up to now, EDM searches focused on neutral systems (neutrons, atoms, and molecules). Storage rings, however, offer the possibility to measure EDMs of charged particles by observing the influence of the EDM on the spin motion in the ring. Direct searches of proton and deuteron EDMs bear the potential to reach sensitivities beyond  $1E-29$  e cm.

Since the Cooler Synchrotron COSY at the Forschungszentrum Jülich provides polarized protons and deuterons up to momenta of 3.7 GeV/c, it constitutes an ideal testing ground and starting point for such an experimental program. The collaboration is presently aiming at a first direct (precursor) measurement of the deuteron EDM in COSY, using an RF Wien filter that was specifically designed for that purpose. Beyond that, the technical design of a prototype EDM storage ring constitutes the next major milestone of the JEDI research program, which shall be addressed together with CERN in the framework of a newly formed CPEDM collaboration (Charged Particle Electric Dipole Moment collaboration).

The talk will present the JEDI plans for the measurement of proton and deuteron EDMs, and discuss the various technical developments, and also show recent results. This work is supported by an ERC Advanced-Grant of the European Union (srEDM, No. 694340).

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## The KLOE-2 Experiment at DAPHNE

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The KLOE-2 experiment at DAΦNE, the LNF Frascati  $\phi$ -factory, has completed its data taking in 2018, collecting 5.5 fb<sup>-1</sup> of integrated luminosity. The goal of KLOE-2 is to extend and expand the physics program of KLOE. The original ‘general purpose’ central detector, made by a large drift chamber - 4 m in diameter - surrounded by a lead/scintillating fibre electromagnetic calorimeter, has been upgraded with new sub-detectors, among which there is a cylindrical GEM detector to improve vertex reconstruction in the interaction region and two taggers to identify leptons diffused at small angles in gamma-gamma interactions.

The 8 fb<sup>-1</sup> acquired with KLOE/KLOE-2 constitute a unique dataset of 24 billions  $\phi$  mesons produced. KLOE data analysis is still providing relevant results on K mesons’ properties, test of discrete symmetries, unitarity test of the CKM matrix, light meson properties,  $\eta$  decays, search for dark forces, hadronic cross section and its contribution to the muon anomalous magnetic moment. We will present the status of recent results and analysis in progress, as well as the KLOE-2 physics program.

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## $\tau$ - $\mu$ lepton flavor universality in $Y(3S)$ decays at the BABAR experiment

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### **The search for proton and deuteron Electric Dipole Moments using storage rings**

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### **Recent results from charged-current semileptonic B decays at LHCb**

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### **Light meson decays at BES III**

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### **The KLOE-2 Experiment at DAPHNE**

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### **Rare and forbidden decays of D0 meson**

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### **Hadronic charm meson decays at BESIII**

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### **Study of resonant-states production in $e^+e^-$ annihilation in the energy region around 2.2 GeV**

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### **Probing of multiquark structure in hadron and heavy ion collisions**

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### **XYZ at BESIII**

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### **Study of resonant-states production in $e^+e^-$ annihilation in the energy region around 2.2 GeV**

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### **Probing NP in four-fermion interactions with dipole processes**

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### **Search for Exotic decays in NA62**

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### **Recent Searches for Hidden-Sector Particles with BABAR**

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## **Baryogenesis and Dark Matter from B Mesons**

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## **Recent CMS results of a search for $\tau \rightarrow 3\mu$ decays**

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## **Finding light DM with Deep Inelastic Scattering at the LHC**

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## **Searching for light scalars in rare B-decays into six muons**

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## **TauFV**

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## **Branching Fraction measurement of $B^0 \rightarrow D^0 D^0 \bar{K} \pi$ at LHCb**

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## **Measurement of the weak mixing phase $\phi_s$ through time-dependent CP violation in $B_s \rightarrow J/\psi\Phi$ decay in ATLAS**

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## **Search for CP violation in Higgs boson interactions at the ATLAS experiment**

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## **Recent highlights of top-quark physics with the ATLAS detector**

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## **Searching for leptoquarks with the ATLAS detector**

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## **Higgs boson couplings to bottom quarks at the ATLAS experiment**

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## **ATLAS results on Heavy Flavour production and decay (including rare processes)**

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## **CKM matrix at Belle II**

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## **Belle II highlights on first B Physics results**

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## **Charm and charmonium at Belle II**

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## **$\tau$ physics results and prospects at Belle II**

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## **“Results and Prospects of Radiative and Electroweak Penguin Decays at Belle II**

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## **Status and Future development of the Full Event Interpretation Algorithm at Belle II**

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## **CMS Measurement of prompt open charm production cross sections in proton-proton collisions at 13 TeV**

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## **Flavour on a forward detector at 50 and 100 TeV**

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## **FPCP 2022 site selection**

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