BEACH 2024: XV International Conference on Beauty, Charm, Hyperons in Hadronic Interactions

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Book of Abstracts

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Session 4 / **1**

Heavy-flavour production and b-hadron lifetime measurements in ATLAS

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Recent results on open heavy flavour and charmonium production from ATLAS experiment with Run-2 data are presented. This covers the double differential measurements of J/ψ and ψ(2S) production, D mesons and B+ production at √s=13 TeV

Session 8 / **4**

Recent results on SUSY searches in ATLAS

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Supersymmetry (SUSY) provides elegant solutions to several problems in the Standard Model, and searches for SUSY particles are an important component of the LHC physics program. This talk will present the latest results from SUSY searches conducted by the ATLAS experiment. The searches target multiple final states and different assumptions about the decay mode of the produced SUSY particles, including searches for both R-parity conserving models and R-parity violating models and their possible connections with the recent observation of the flavour and muon g-2 anomalies. The talk will also highlight the employment of novel analysis techniques, including advanced machine learning techniques and special object reconstruction, that are necessary for many of these analyses to extend the sensitivity reach to challenging regions of the phase space.

Session 4 / **5**

Precision measurements of Standard Model parameters in ATLAS

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ATLAS has used the W and Z boson production processes to perform a range of precision measurements of SM parameters. The recoil of the Z-boson is sensitive to quark and gluon emissions and is used to determine the strong coupling constant in a novel approach. The production rate of Z+jet events with large missing transverse momentum is used to measure the decay width of the Z boson decaying to neutrinos. Differential measurements of this topology with minimal assumptions on theoretical calculations are discussed and allow comparisons to the Standard Model as well as

the interpretation in beyond-the-Standard-Model scenarios. The LHC pp collision data collected by the ATLAS experiment at sqrt(s)=7 TeV is revisited to measure the W boson mass and its width. Finally, the ratio of branching ratios of the W boson to muons and electrons has been measured from top-antitop production cross sections, confirming the Standard Model assumption of lepton flavour universality in W-boson decays at the 0.5% level.

Session 8 / **6**

Vector-like quarks, leptoquarks and new gauge bosons search in Atlas

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The Standard Model of Particle Physics explains many natural phenomena yet remains incomplete. Leptoquarks (LQs) are hypothetical particles predicted to mediate interactions between quarks and leptons, bridging the gap between the two fundamental classes of particles. Vectorlike quarks (VLQs) lie at the heart of many extensions seeking to address the Hierarchy Problem, as they can naturally cancel the mass divergence for the Higgs boson. Many new physics models predict the existence of new, heavy particles. This talk summarizes recent ATLAS searches for Beyond-the-Standard-Model heavy resonances (LQ, VLQ, and other new gauge bosons) which decay to quarks, or leptons, using Run 2 data collected at the LHC.

Session 4 / **8**

LFU tests in semileptonic decays at LHCb

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The semileptonic decays of b-hadrons are a rich source of observables sensitive to Standard Model and New Physics paramaters.
In the last decade, measurements of ratios of decay rates between the tauonic and the muonic tree level $b \to c$ transitions,
have hinted at potential violations of the Lepton Flavour Universality, which require further investigation.

This talk presents the most recent results of LFU tests performed studying the semileptonic $b \to c$ transitions at LHCb:
the ratios of branching fractions of $B \to D(*)\tau\nu$ and $B \to D(*)\mu\nu$ decays,
and the measurement of the D^* longitudinal polarization in $B \to D^*\tau\nu$ decays.

Session 5 / **9**

Charm physics at LHCb

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LHCb has collected the world's largest sample of charmed hadrons. This sample is used to measure the $D^0 - \overline{D}^0$ mixing, to search for rare decays and for CP violation, and to perform precise measurements of properties and production of known charmed mesons and baryons. New measurements of several decay modes are presented, along with prospects for the sensitivity at the LHCb upgrades.

Session 3 / **10**

Time-independent gamma determinations at LHCb

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The tree-level determination of the CKM angle gamma is a standard candle measurement of CP violation in the Standard Model. The latest LHCb results from time-integrated measurements of CP violation using beauty to open charm decays are presented. The talk will focus on the B -> D*K and B0 -> DK*0 decays modes using a variety of charm decays, which are the latest measurements using data collected during Run1 and Run 2 of the LHCb experiment. The precision achievable with both these modes is competitive and they add significant knowledge to the measurement of the CKM angle gamma. They also resolve the recent tension between measurements originating from B+ and B0 meson decays.

Session 4 / **11**

LHCb measurements of rare electroweak decays of b-hadrons

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In the Standard Model, decays mediated by $b \to sll$ are very suppressed making them sensitive to possible non-SM contributions.
The latest LHCb measurement of the branching fraction ratio of this process between electrons and muons was shown to be consistent with the Standard Model.
However, measurements of branching fraction and angular observables of $b \to s\mu\mu$ have shown an interesting pattern of tensions with the predictions.
This could be due to underestimated hadronic effects or non-SM contributions.
The most recent LHCb measurements as well as future prospects to understand this will be discussed in this talk.

Session 6 / **12**

Large-Nc methods for baryons

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Considering QCD in the limit of the number of colors N_c being large provides important constraints on the interactions between baryons. These constraints are particularly valuable when the available data is too limited to accurately determine the interactions. In particular, while symmetry-preserving nucleon-nucleon interactions are constrained from a large amount of scattering data, interactions that violate symmetries, e.g., parity and time reversal invariance, and operators contributing to neutrinoless double beta decay are not well known. In the absence of sufficient data, the constraints provided by the large-N_c expansion may prove useful in guiding both experiment and theory in prioritizing where to focus efforts to gain a better understanding of the baryon-baryon interactions. I will describe recent applications with a focus on nucleon-nucleon interactions and combining large-N_c with other effective field theory methods.

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Study of proton-nucleus interactions with the DsTau/NA65 experiment at the CERN-SPS

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The DsTau (NA65) experiment at CERN was proposed to measure an inclusive differential cross-section of production, and its decay branching ratios in p-A interactions. The DsTau detector is based on the nuclear emulsion technique providing an excellent spatial resolution for detecting short-lived particles like charmed hadrons. The first results of the analysis of the pilot-run data are presented. The accuracy of the proton interaction vertex reconstruction is reported. A high precision in vertex reconstruction allows one to measure the proton interaction length and charged particle multiplicities accurately in a high-track density environment. The measured data have been compared with several Monte Carlo event generators in terms of multiplicity and angular distribution of charged particles. The proton interaction length in tungsten is measured to be mm. The predictions of KNO-G scaling are tested on the multiplicity distribution in p-A interactions. The results presented in this study can be used to validate event generators of p-A interactions.

Session 3 / **14**

B-physics results from Belle and Belle II

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The Belle II experiment has collected a 424 fb^{-1} sample of e^+e^- collisions produced by the asymmetric SuperKEKB collider. Ninety percent of the sample is at the $\Upsilon(4S)$ resonance, which decays to B-meson pairs. The predecessor experiment, Belle, collected nearly 1 ab^{-1} of data from 1999-2010, three-quarters of which was at the $\Upsilon(4S)$. From these $\Upsilon(4S)$ data, we have made measurements of rare B decays and CP violation, as well as searched for lepton-universality violation. Highlights include the first observation of $B \to K\nu\bar{\nu}$ and measurements of lepton-universality in semitauonic B decays.

Session 5 / **15**

Charm results at Belle and Belle II

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The Belle and Belle II experiments have collected a $1.4\ \mathrm{ab}^{-1}$ sample of e^+e^- collision data at centre-of-mass energies near the $\Upsilon(nS)$ resonances. These samples contain a large number of $e^+e^- \to c\bar{c}$ events that produce charmed mesons. Direct CP violation is searched for in $D^0 \to K^0_S K^0_S$ decays and D-meson decays to a four-body final state. For the four-body decays, asymmetries in the distributions of triple and quadruple moments probe for CP violation. We present searches for rare flavour-changing neutral current $c \to u\ell^+\ell^-$ processes in several decay modes. Further, we study several decays of the Λ_c and Ξ_c to determine branching fractions, as well as CP asymmetries in singly Cabibbo-suppressed decays.

Session 1 / **16**

Studies of hadron spectroscopy at Belle and Belle II

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The Belle and Belle II experiments have collected a $1.4\ \mathrm{ab}^{-1}$ sample of e^+e^- collision data at centre-of-mass energies near the $\Upsilon(nS)$ resonances. These data include a 19.2 fb^{-1} sample collected near the $\Upsilon(10753)$ resonance to probe its potentially exotic nature. We present several results related to the following processes: $e^+e^- \to \Upsilon(nS)\eta$, $e^+e^- \to \gamma X_b(\chi_{bJ}\pi^+\pi^-)$, $e^+e^- \to h_b(1P)\eta$ and $e^+e^- \to \chi_{bJ}(1P)\omega$. The last analysis also includes data samples collected by Belle at similar centre-of-mass energies. In addition, we present Belle measurements of the B^0 and B^+ meson mass difference, a pentaquark search in $\Upsilon(1S)$ and $\Upsilon(2S)$ decays, as well as studies of $h_b(2P)$ decays to the $\eta\Upsilon(1S)$ and $\chi_{bJ}\gamma$ final states.

Session 3 / **17**

Searches for hidden sectors and lepton flavour violation in kaon decays

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Rare kaon decays are among the most sensitive probes of both heavy and light new physics beyond the Standard Model description thanks to high precision of the Standard Model predictions, availability of very large datasets, and the relatively simple decay topologies. The NA62 experiment at CERN is a multi-purpose high-intensity kaon decay experiment, and carries out a broad rare-decay and hidden-sector physics programme. NA62 has collected a large sample of K^+ decays in flight during Run 1 in 2016-2018, and the ongoing Run 2 which started in 2021. Recent NA62 results on searches for hidden-sector mediators and searches for violation of lepton number and lepton flavour conservation in kaon decays based on the Run 1 dataset are presented. Future prospects of these searches are discussed.

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Hyperon physics at BESIII

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With the large datasets on ⊠+⊠−-annihilation at the ⊠/⊠ and ⊠(3686) resonances collected at the BESIII experiment, multi-dimensional analyses making use of polarization and entanglement can shed new light on the production and decay properties hyperon-antihyperon pairs. In a series of recent studies performed at BESIII, significant transverse polarization of the (anti)hyperons has been observed in ⊠/⊠ or ⊠(3686) to ΛΣ-bar , ΣΣ-bar , ΞΞ-bar .The decay parameters for the most common hadronic weak decay modes were measured, and due to the non-zero polarization, the parameters of hyperon and antihyperon decays could be determined independently of each other for the first time. Comparing the hyperon and antihyperon decay parameters yields precise tests of direct, Δ⊠ = 1 CP-violation that complement studies performed in the kaon sector.

Session 2 / **19**

Cross-sections of e+e- annihilation into open or hidden charm states

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This presentation will discuss three recent measurements conducted at BESIII of the cross-sections of electron-positron annihilation into open or hidden charm final states. The first measurement utilizes e+e- collision data collected at BESIII, spanning center-of-mass energies from the threshold to 4.95 GeV. Precise measurements of the cross-sections of e+ e- -> Ds+ Ds- have been performed. The resulting cross-section lineshape reveals several new structures, providing valuable input for coupled channel analysis and model testing. The second measurement utilizes data samples at center-of-mass energies ranging from 3.80 to 4.95 GeV, corresponding to an integrated luminosity of 20/fb. The measurements of Born cross-sections for the e+ e- -> D0D0bar and D+D- processes are presented with unprecedented precision. A series of intriguing structures are observed in the lineshape of the

cross-sections. The third measurement uses data samples with an integrated luminosity of 22.42/fb at center-of-mass energies from 3.808 to 4.951 GeV. The measurements of cross-sections of the e+ e- -> eta J/psi have been updated. A maximum-likelihood fit with psi(4040), two additional resonances, and a non-resonant component is performed. The mass and widths of the two additional states are consistent with those of the previously found psi(4230) and psi(4360).

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New observations in charmonium decays at BESIII

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This presentation will explore recent experimental findings in the domain of charmonium decays, encompassing four independent measurements conducted at BESIII. 1) Utilizing 27B psi(3686) events collected with the BESIII detector, various hc decays have been sought and measured. The decay channel hc -> 3(pi+pi-)pi0 has been observed for the first time, with strong evidence of hc -> 2(pi+ pi-)pi0 eta and 2(pi+ pi-)omega. 2) The observation of the psi(3686) -> 3phi. This observation illuminates the rare decay process of the psi(3686) resonance into three phi mesons, providing valuable insights into the dynamics of charmonium decays. No significant structure is observed in the phi phi invariant mass. 3) The search for eta_c(2S) -> pi+ pi- eta_c and eta_c(2S) -> pi+ pi- Ks0 K+/- pi-/+ decays. This study aims to explore the decay properties of the eta_c(2S) meson, offering new perspectives on its decay modes and contributing to our understanding of charmonium states. 4) The observation of chi_cJ -> 3(K+ K-). All the decays from chi_c0, chi_c1, and chi_c2 are observed for the first time.

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Search for dark sector and Axion-like particle at BESIII

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BESIII is a symmetric e+e- collider operating at c.m. energy from 2.0 to 4.95 GeV. With the world's largest data set of J/psi (10 billion), psi(3686) (2.6 billion), and about 25 fb^-1 scan data from 3.77 to 4.95 GeV, various dark sectors produced in e+e- annihilation and meson decay processes can be searched for at BESIII. Axion-like particles (ALPs) are pseudo-Goldstone bosons arising from some spontaneously broken global symmetry, addressing the strong CP or hierarchy problems. In this talk, we report the search for invisible dark photon decays using initial state radiation, search for invisible muonic Z' boson decays, and search for axion-like particles with a light scalar or vector particle in the muonic decay of J/psi.

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Baryon/Lepton number violation searches at BESIII

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The observed matter-antimatter asymmetry in the universe composes a serious challenge to our understanding of nature. In various experiments, BNV/LNV decays have been searched for to understand this large-scale observed fact, and few in the case of collision experiments are performed. In this talk, we present recent results to search for BNV and LNV decays from charmed meson, hyperons and light hadrons at the BESIII experiment.

Session 2 / **23**

Search for charged lepton flavor violation at BESIII

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The charged Lepton Flavor Violation (cLFV) is highly suppressed in the Standard Model (SM) by the finite but tiny neutrino masses. Its branching fraction is calculated to be at a negligible level and so far, none has been found in experiments, including searches in lepton (μ, τ) decays, pseudoscalar meson (K, π) decays, vector meson (ϕ, J/ψ, Υ) decays, and Higgs decays etc. This talk presents the charged Lepton Flavor Violation searches at the BESIII experiment. The $J/psi- > etau/emu$ is searched for with 10 billion J/ψ events collected by BESIII and the result improves the previously published limit by two orders of magnitude.

Session 6 / **24**

Precision measurements with kaon and pion decays at CERN

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The NA62 experiment at CERN collected the world's largest dataset of charged kaon decays in 2016-2018, leading to the first measurement of the branching ratio of the ultra-rare $K^+ \to \pi^+\nu\bar{\nu}$ decay, based on 20 candidates. In this talk NA62 reports new results from the analyses of rare kaon and pion decays, using data samples collected in 2017-2018.
A sample of $K^+ \to \pi^+\gamma\gamma$ decays was collected using a minimum-bias trigger, and the results include measurement of the branching ratio, study of the di-photon mass spectrum, and the first search for production and prompt decay of an axion-like particle with gluon coupling in the process $K^+ \to \pi^+ A$, $A \to \gamma\gamma$. A sample of $\pi^0 \to e^+e^-$ decay candidates was collected using a dedicated scaled down di-electron trigger, and a preliminary result of the branching fraction measurement is presented. Recent results from analyses of $K^+ \to \pi^0 e^+\nu\gamma$ and $K^+ \to \pi^+\mu^+\mu^-$ decays using 2017-2018 datasets are also presented. The radiative kaon decay $K^+ \to \pi^0 e^+\nu\gamma$ (Ke3g) is studied with a data sample of O(100k) Ke3g candidates with sub-percent background contaminations. Results with the most precise measurements of the Ke3g branching ratios and T-asymmetry are presented. The $K^+ \to \pi^+\mu^+\mu^-$ sample comprises about 27k signal events with negligible background contamination, and the presented analysis results include the most precise determination of the branching ratio and form factor.
The first observation of the decay $K^\pm \to \pi^0\pi^0\mu^\pm\nu$ (K00μ4) by the NA48/2 experiment at the CERN

and the final measurement of the branching ratio are also presented. The result is converted into a first measurement of the R form factor in Kl4 decays and compared with the prediction from 1-loop Chiral Perturbation Theory.

Session 5 / **25**

The charmed meson decays at BESIII

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BESIII has collected 2.93 and 7.33 fb^-1 of e+e- collision data samples at 3.773 and 4.128-4.226 GeV, which provide the largest dataset of DDbar and DsDs pairs in the world, respectively.
As for the hadronic decays, we will present the observation of D+ to Ks a0(980) and a new a0-like state with a mass of 1.817 GeV, and the determination of U-spin breaking parameters of the decay D0 to KL pi+ pi-, along with the amplitude analyses of D0(+) to 4pi and D+ to Kspi+pi0pi0. Our presentation will also include the latest measurements of quantum-correlated DD decays, including the CP-even fraction of D0 to Kspi+pi-pi0, KKpipi, and more.
As for the (semi-)leptonic decays, we will present the first experimental study of Ds* to e nu and the improved measurements of |Vcs| and Ds decay constant in Ds+ -> mu+ nu and tau+ nu. Furthermore, we will present the Ds->eta(‘), Ds->f0(980), and Ds->phi form factor studies in Ds+->eta(‘) l+ nu, Ds+->pi+pi- e+ nu, and Ds+->K+K- l+ nu.

Session 5 / **26**

Charmed baryon decays at BESIII

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BESIII has accumulated 4.5 fb^-1 of e+e- collision data within the 4.6 and 4.7 GeV energy range, presenting a unique opportunity to investigate Lambda_c+ decays. Our presentation will include the first measurement of the decay asymmetry in the pure W-boson-exchange decay Λ_c^+⟶Ξ^0 K^+, as well as the study of Lambda_c+ -> Lambda l+ nu and the branching fraction measurements of the inclusive decays Lambda_c+->X e+ nu and Lambda_cbar- -> nbar X.
Furthermore, we will present the results of the partial wave analysis of Lambda_c+ -> Lambda pi+ pi0, and the latest branching fraction measurements of Cabibbo-suppressed and -favored Lambda_c+ decays, including Lambda_c to p pi0, Sigma- K+ pi+, p eta (omega), and more.

Session 2 / **27**

Theoretical Perspectives on Lepton Flavor Violation

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We provide an overview of lepton flavor violation from a theoretical perspective, both using the effective field theory framework and a variety of concrete models, motivated, for example, by the observation of neutrino masses. We also discuss non-standard signatures such as light-boson emission and flavor violation by more than one unit, highlighting challenges and opportunities at future facilities.

Session 6 / **29**

KOTO: Search for $K_L^0 \to \pi^0 \nu \overline{\nu}$

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KOTO is the dedicated experiment to study the CP-violating decay $K_L^0 \to \pi^0 \nu \overline{\nu}$. This decay is sensitive to New Physics because its branching ratio is predicted to be 3×10^{-11} with only 2\% theoretical uncertainty. By using the data collected in 2021, we have set the worldwide best limit on the branching ratio of this decay to be 2.0×10^{-9} at the 90% confidence level. KOTO is expected to collect ten times more data within the following 4 years and explore the New-Physics-sensitive regime. We are also preparing for the next-generation experiment, KOTO-II, to accurately examine the Standard Model. The analysis status and future plan will be summarized in this talk.

Session 5 / **30**

Threshold charmonium production at JLab

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The 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) at JLab allows the study of J/ψ photoproduction and some higher-mass charmonium states at their thresholds, starting from 8.2 GeV. In this regime, the reaction amplitude is dominated by its real part (in contrast to the high-energy case) and contains important information about the interactions of the c-cbar pair with the proton target at low energy. This amplitude can be related to the gluon properties of the nucleon such as gluon form factors, mass radius of the proton, and the anomalous contribution to the proton mass. Threshold J/ψ production can also be used to study the J/ψN scattering length and the possibility of J/ψN bound states like the LHCb pentaquarks. We discuss the results of two JLab experiments, GlueX and J/ψ-007, where we aim to extract the above quantities from J/ψ production and test the theoretical assumptions used to relate those quantities to the measured cross sections. These studies are complemented by observations of higher-mass charmonium states in the GlueX experiment. The proposed 22 GeV CEBAF upgrade would allow more comprehensive studies of the above reactions, also using polarization measurements, and at the same time increase the energy reach well above the D-Dbar threshold.

Session 6 / **31**

Observation of the Sigma+ -> p mu+ mu- rare decay

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The Sigma+ -> p mu+ mu- decay is observed for the first time at the LHCb experiment.
This is a flavour changing neutral current sensitive to physics beyond the Standard Model, which could modify it's properties.
In particular the HyperCP experiment years ago presented an evidence of this decay with a hint of a possible unknown intermediate particle.
This was excluded by LHCb already in 2018. This new measurement presents a highly significant observation and a measurement of its integrated and differential branching fraction. This is the rarest baryon decay ever observed.
Additionally, the sensitivity of these observables to Chiral Perturbation Theory parameters will be discussed.
Finally prospects for additional observables, such as a CP violation measurement, will also be presented.

Session 3 / **32**

Probing sterile neutrinos in bottom and charm decays

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We explore several channels in bottom and charm quark decays that can be affected by the presence of a sterile neutrino. We will discuss strategies to find signatures of the sterile neutrino in these decays at various experiments such as Belle II, FASER and DUNE. Finally, we will address the recent measurement of B \to K invisible in a dark sector model with a sterile neutrino.

Session 7 / **33**

Precision Measurement of the Muon Magnetic Moment Anomaly at the Fermilab Muon g-2 Experiment

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The Fermilab Muon g-2 Experiment measured the muon magnetic moment anomaly to a precision of 200 parts per billion (ppb), after combining data from 2019 and 2020 with those from 2018. It involves high-precision measurements of the anomalous muon spin precession frequency ω_a, as well as the magnetic field experienced by the muons. ω_a is measured with polarized muons decaying in a dipole magnetic field inside a storage ring. The parity violation property of polarized muon weak decay causes the measured decay rate above an optimized energy threshold to fluctuate over time at a frequency ω_a, which is extracted through fitting. Additional corrections are applied to account for beam dynamics effects. On the other hand, the magnetic field is measured using Nuclear Magnetic Resonance (NMR) probes. Absolutely calibrated NMR probes mounted on a survey trolley measure the magnetic field inside the muon storage ring, and fixed NMR probes located at various locations

around the ring track the field over time. The measurements are synchronized and interpolated, then averaged over space and time, and weighted by the muon density. Transient magnetic field influences are addressed by additional corrections. The uncertainty in the newly released data was improved over multiple aspects other than statistics. Better running conditions, more systematic studies, and analysis improvements all contributed to the 70-ppb systematic uncertainty of the new result, surpassing the 100-ppb proposal goal.

Session 1 / **34**

Heavy Quark Exotic States

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Heavy quark exotic candidates continue to be observed at CERN and other laboratories. A survey of the field is made with focus on whether an organizational scheme for the multitude of states is possible.

Session 1 / **35**

Hadronization of heavy b quarks at LHCb

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The differences in hadron chemistry observed at e+e- machines versus hadron colliders indicates that the mechanisms by which partons evolve into visible matter are not universal. In particular, the presence of many other quarks produced in the underlying event may allow new hadron production mechanisms to come into play. With full particle ID, precision vertexing, and a high rate DAQ, the LHCb detector is uniquely well suited to study heavy quarks. This contribution will present recent LHCb data on the production rates of various hadrons containing heavy bottom quarks, and discuss how this data affects our understanding of the hadronization process.

Session 4 / **36**

Search for Baryogenesis and Dark Matter in B-meson decays at $BABAR$.

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We present the most recent $BABAR$ searches for reactions that could simultaneously explain the presence of dark matter and the matter-antimatter asymmetry in the Universe. This scenario predicts

exotic B-meson decays of the kind $B \to \psi_D calB$, where

$calB$ is an ordinary matter baryon (proton, Λ, or Λ_c) and ψ_D is a dark-sector anti-baryon, with branching fractions accessible at the B factories. The hadronic recoil method has been applied with one of the B mesons from $\Upsilon(4S)$ decay fully reconstructed, while only one baryon is present in the signal B-meson side. The missing mass of signal B meson is considered as the mass of the dark particle ψ_D. Stringent upper limits on the decay branching fraction are derived for ψ_D masses between 0.5 and 4.3 GeV/c^2. The results are based on the full data set of about 430 fb^{-1} collected at the $\Upsilon(4S)$ resonance by the $BABAR$ detector at the PEP-II collider.

Session 7 / **37**

New BABAR studies of high-order radiation and the new landscape of data-driven hadronic vacuum polarization predictions of the muon g-2

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A dedicated measurement of additional radiation in $e^+e^- \to \mu^+\mu^-\gamma$ and $e^+e^- \to \pi^+\pi^-\gamma$ initial-state-radiation events is presented using the full $BABAR$ data sample. For the first time results are presented at next-to-leading and next-to-next-to-leading order, with one and two additional photons, respectively, for radiation from the initial and final states. The comparison with predictions from Phokhara and AfkQed Monte Carlo generators reveals discrepancies for the former in the one-photon rates and angular distributions. While this disagreement has a negligible effect on the $e^+e^- \to \pi^+\pi^-(\gamma)$ cross section measured by $BABAR$, the impact on the KLOE and BESIII cross-section measurements is estimated and found to be indicative of systematic effects larger than uncertainties assigned. The new situation also warrants a reappraisal of the independent information provided by hadronic $/tau$ decays, including state-of-the-art isospin-breaking corrections. The findings shed a new light on the longstanding deviation between the muon $g-2$ measurement and the Standard Model prediction using the data-driven dispersive approach, and the comparison with lattice QCD calculations.

Session 3 / **38**

Recent developments in HQET

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In this talk I review recent perturbative and non-perturbative developments in Heavy Quark Effective Theory (HQET).

Session 4 / **39**

Light Dark Matter Contribution to Lifetime Difference of Heavy Neutral Mesons

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Heavy meson decays with missing energy in final state offer interesting avenues to search for light dark matter (DM) particles. In this context, we show that such DM interactions also affect lifetime difference in neutral meson-antimeson mixing. We consider general dimension-six effective quark interactions involving a pair of light DM fields, and calculate their contributions to lifetime difference in beauty and charm meson systems. We use the latest data on mixing observables to constrain the DM interactions under consideration. Our findings reveal that lifetime differences provide both novel and complementary flavor constraints compared to those obtained from heavy meson decays.

Session 7 / **40**

Instrumental uncertainties in radiative corrections for the MUSE experiment

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The MUSE experiment at the Paul Scherrer Institute is measuring elastic lepton-proton scattering cross sections in a four-momentum transfer range from Q2 of approximately 0.002 to 0.08 GeV2 using positively and negatively charged electrons and muons. The extraction of the Born cross sections from the experimental data requires radiative corrections. Estimates of the instrumental uncertainties in those corrections have been made using the ESEPP event generator. The results depend in particular on the minimum lepton momentum that contributes to the experimental cross section and the fraction of events with hard initial-state radiation that is detected in the MUSE calorimeter and is excluded from the data. These results show that the angular-dependent instrumental uncertainties in radiative corrections to the electron cross section are better than 0.4 % and are negligible for the muon cross section.

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Session 1 / **41**

Production of Heavy Quarks and Quarkonium

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We discuss open heavy flavor and quarkonium production in $p+p$ and $p+A$ collisions. We describe cold nuclear matter effects in the context of $p+A$ collisions.

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Session 1 / **42**

Characterizing the charm-quark showering and hadronization via charm-jet studies with ALICE

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The properties of parton shower in QCD depend on the flavor of the parton involved in the $1 \longrightarrow 2$ splitting processes that drive the showers. In particular, they are sensitive to the different Casimir factors of quarks and gluons, as well as to parton mass effects. To explore these dependencies, we use heavy-flavor jets as an experimental tool, with a particular focus on the low transverse momentum region, where mass effects are significant.

The ALICE detector has excellent tracking and particle identification performance, enabling the tagging of jets with fully reconstructed heavy-flavor hadrons. These capabilities are essential for jet substructure studies as they allow us to identify and trace a specific quark flavor through the splitting tree.

I will present the recent results of charm-tagged jets, reconstructed from D^0-mesons or Λ_c-baryons, and their substructure, obtained by ALICE at the LHC. These results include the first direct measurement of the dead-cone effect at colliders, measured exploiting iterative declustering techniques, the radial distribution of D^0-mesons with respect to the jet axis, and the first measurement of the jet angularity, an observable that can be tuned to be sensitive to mass and Casimir effects. Additionally, I will show the groomed shared momentum fraction of the first perturbative parton splitting, as well as the opening angle of the first perturbative emission of the charm quark, measured from D^0-tagged jets. These jet substructure observables are linked to fundamental ingredients of the splitting functions. Comparisons to an inclusive jet sample will probe the parton-shower flavor dependencies related to the large mass of the charm quark, as well as the high-purity quark nature of the charm-tagged jet sample. Furthermore, I will present comparisons of results between charm-tagged meson and charm-tagged baryon jets, shedding light on the processes of charm hadronization.

Session 7 / **43**

Status of the The Muon Scattering Experiment (MUSE) at PSI

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The MUon proton Scattering Experiment (MUSE) simultaneously measures elastic electron-proton and muon-proton scattering using the PiM1 beam line at Paul Scherrer Institute in Villigen, Switzer-

land. Using both positive and negative beam polarities, MUSE will extract the proton charge radius by scattering off a liquid hydrogen target and contribute precise data to the investigation of the proton radius puzzle. MUSE also aims to test lepton universality, radiative corrections, and two-photon exchange effects for electrons and muons by comparing the scattering cross sections for electrons and muons at both polarities. This presentation will give an update on the current status and plans for MUSE.

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Session 2 / **44**

Hadronic Molecule Effective Field Theory for T_cc^+

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The T_cc^+ is a a doubly charmed tetraquark that lies very close to the D^* D meson thresholds. As such it can be described as a molecular bound state in an effective field theory (EFT) of heavy mesons. An EFT calculation of the width is in excellent agreement with experiment and also successfully reproduces the invariant mass spectrum of the D mesons in the three body decays of the T_cc^+. This latter observable is particularly sensitive to the molecular nature of the T_cc^+. An NLO calculation in EFT continues to be in excellent agreement with experiment and leading sources of uncertainty are sensitive to scattering properties of D mesons.

Session 8 / **45**

Review of neutrino physics (exp)

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Neutrinos are central to many questions in particle physics, nuclear physics, and cosmology. I will give an overview of what we have learned about neutrino properties, their masses, their mixings, and their symmetries from experiments and what we have to look forward to from future experiments.

Session 2 / **46**

The Mu2e Experiment: A Charged Lepton Flavor Violation (CLFV) Search

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Charged Lepton Flavor Violation (CLFV) processes are transitions involving electrons, muons, or tau leptons that do not preserve lepton family numbers, and they provide model-independent probes of new physics beyond the Standard Model. The Mu2e experiment at Fermilab will search for the CLFV neutrino-less muon-to-electron conversion in the presence of aluminum nuclei, through the detection of a single monoenergetic electron of 105-MeV energy as the signal. The Mu2e experiment aims for a single-event sensitivity of 3×10^{-17}, which will set an upper limit of 8×10^{-17} at 90% confidence level for the conversion-to-capture ratio, improving the current experimental limit by four orders of magnitude. This presentation discusses the detectors of the Mu2e experiment and the strategies to reduce experiment backgrounds. Recent developments in the experiment installation and commissioning are highlighted.

Session 7 / **48**

Theoretical Advances in g-2 (lattice)

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The muon's anomalous magnetic moment is now known with a precision of 0.19 ppm with the latest run-2 and run-3 results of the Fermilab g-2 experiment. Further improvement in the precision of the experimental result is expected in the near future as the analysis of the final, subsequent run's 4, 5 and 6 are underway. On the theoretical side, the largest source of uncertainty in the 0.37 ppm determination from the muon g-2 theory initiative white-paper is the hadronic vacuum polarization (HVP) contribution, followed by the sub-leading hadronic light-by-light (HLbL) contribution. Lattice QCD provides a systematically-improvable approach for obtaining these quantities with minimal experimental input. In this talk I will provide an overview of the current status of the lattice g-2 community's ongoing efforts to calculate the HVP and HLbL contributions to a level of precision commensurate with experiment.

Session 6 / **49**

Precision measurements of charged pion decays with the PIONEER Experiment

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PIONEER is a next-generation precision experiment proposed at Paul Scherrer Institute, Switzerland, to perform high precision measurements of rare pion decays. The measurement of the charged pion branching ratio $R_{e/}$ = Γ(π+⟶e+ν(γ) / Γ(π+⟶ μ+ν(γ) for pion decays to positrons relative to muons is extremely sensitive to a wide variety of new physics effects. At present, the Standard Model prediction for $R_{e/}$ is known to the order of 10^{-4}, which is 15 times more precise than the current experimental result. An experiment reaching the theoretical accuracy will test lepton flavor universality at an unprecedented level, probing mass scales up to the PeV range. The measurement of the rare process of pion beta decay, π+⟶ π^0e+ν(γ) with an improvement in sensitivity by a factor of 3-10, will determine $|V_{ud}|$ in a theoretically pristine manner and test CKM unitarity, which is very important in light of the recently emerged tensions. In addition, various exotic rare decays involving sterile neutrinos and axions will be searched for with unprecedented sensitivity.
The experiment design benefits from experience with the PIENU and PEN experiments at TRIUMF

and at PSI. Excellent energy and time resolutions, greatly increased calorimeter depth, high-speed detector and electronics response, large solid angle coverage, and complete event reconstruction are all critical aspects of the approach. In the PIONEER experiment design, an intense pion beam is stopped in a segmented, instrumented (active) target (ATAR). The proposed technology for the ATAR is based on low-gain avalanche detectors (LGADs), which can provide precise spatial and temporal resolution for particle tracks and thus separate even very closely spaced decays and decay products. The proposed detector will also include a ~2π sr, 25 radiation length (X_0) electromagnetic calorimeter. An additional, cylindrical tracker surrounding the ATAR may be used to link the locations of pions stopping in the target to showers in the calorimeter.
This presentation will cover the theoretical motivations for PIONEER, as well as the ongoing simulations efforts to precisely determine the detector performance and inform decisions on the experiment design. Results from recent beam test campaigns on the pion beamline itself, and silicon sensor and LYSO calorimeter crystal prototypes will be shown.

Session 8 / **50**

Theory of neutrinos

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I will provide a discussion of open questions surrounding neutrinos and how they connect to particle physics at large. I specifically, will also provide a review of the various low-energy experimental anomalies.

Session 3 / **51**

An axion-like particle explanation of $B \to \pi K$ puzzle and $B \to K\nu\bar{\nu}$ excess

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In light of the recent branching fraction measurement of $B^+ \to K^+\nu\bar{\nu}$-decay and its deviation from the SM expectation, we analyze the prospect of an axion-like particle (ALP) as the cause of such a departure. We assume a long-lived ALP with a mass of the order of a pion that predominantly decays to two photons. We assess the scenario where the ALP decay length is several meters and therefore has a non-negligible probability to decay outside the detector volume of Belle-II mimicking the $B^+ \to K^+\nu\bar{\nu}$-signal. Remarkably, such an arrangement provides a simple explanation to the long-standing $B \to \pi K$-puzzle by noting that the measured $B^0 \to \pi^0 K^0$ and $B^+ \to \pi^0 K^+$ decays have a $B^0 \to aK^0$ and $B^+ \to aK^+$ component respectively. We also argue based on our results that the axion-photon effective coupling belongs to a region in the parameter space that can be probed in future experiments.

Session 8 / **52**

Future Opportunities in Neutrinoless Double Beta Decay searches

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Neutrinoless Double Beta Decay (NLDBD) searches offer the most sensitive tests of Lepton Flavor Violation. The discovery of NLDBD would have profound consequences: it would establish neutrinos as Majorana particles, it would be the demonstration of a matter-creating process, and it would offer corroborating evidence for leptogenesis – one of the possible answers to the question of our why we exist – which is fun to discuss with a random neighbor on an airplane. I will briefly discuss the current status of NLDBD searches and will focus on the opportunities for discoveries with ton-scale and even larger future NLDBD experiments.

Session 8 / **53**

Nuclear Matrix Elements for Neutrinoless Double-Beta Decay

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I discuss recent and imminent progress in the computation of the nuclear matrix elements that govern neutrinoless double-beta decay. Lattice QCD, effective field theory, and ab initio nuclear structure all play a role in those computations. Bayesian model mixing promises to produce a reliable uncertainty estimate for the computed matrix elements.

Session 5 / **54**

□ / □ photoproduction near threshold in holographic QCD

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We present a holographic analysis of diffractive photoproducton of charmonium J/ψ on a proton, considered as a bulk Dirac fermion near threshold. Using the bulk wave functions of the proton and vector mesons, within holographic QCD, and employing Witten diagrams in the bulk, we compute the diffractive photoproduction amplitude of J/ψ. The holographic amplitude is dominated by the exchange of 2++ and 0++ glueball resonances near threshold. The differential cross section is controlled by the gravitational form factors A(t) and D(t), and compare well to the recent results reported by the GlueX and J/Ψ−007 Collaborations at JLab.

Session 8 / **56**

The progress of Super Tau Charm Facility in China

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The proposed STCF is a symmetric electron-positron beam collider designed to provide e+e− interactions at a centerof-mass energy from 2.0 to 7.0 GeV. The peaking luminosity is expected to be 0.5×10^35 cm−2s−1. STCF is expected to deliver more than 1 ab−1 of integrated luminosity per year. The huge samples could be used to make precision measurements of the properties of XYZ particles; search for new sources of CP violation in the strange-hyperon and tau−lepton sectors; make precise independent mea-surements of the Cabibbo angle (theta)c) to test the unitarity of the CKM matrix; search for anomalous decays with sensitivities extending down to the level of SM-model expectations and so on. In this talk, the physics interests will be introduced as well as the the recent progress on the project R&D.

Session 1 / **57**

Welcome

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Session 3 / **58**

Lattice QCD for heavy flavors

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Session 6 / **59**

Hyperon physics at JLab

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Session 6 / **60**

Aspects of Physics at Jefferson Lab's Halls A, B, and C

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CEBAF delivers the world's highest intensity and highest precision multi-GeV electron beams and has been do so for more than 25 years. In Fall 2017, with the completion of the 12 GeV upgrade and the start of the 12 GeV science program, a new era at the Laboratory began. The 12 GeV era is now well under way and many experimental results are delivered from the three Halls A, B, and C that receive electron beams.

This talk will cover measurements of the J/ψ photo- and electroproduction cross section near threshold by different experiments in Halls B and C, the spectroscopy of strange and multi-strange baryons with the CLAS12 spectrometer in Hall B, and the rich program in hypernuclear physics that will get addressed by an extended measurement campaign in Hall C. Future equipment in Hall A (SoLID) will extend the J/ψ studies in photo- and electroproduction with increased luminosity and kinematic reach.

Session 2 / **61**

Studying the interaction between charm and light-flavor mesons

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In the last years, several exotic hadrons have been observed in the charm sector; such particles cannot be interpreted as conventional baryons or mesons and are thought to be either quark bags or molecular states. To unveil their nature, it is crucial to experimentally constrain the strong force that governs the interaction between the charm hadrons and other hadrons, for instance, by measuring the scattering parameters. This knowledge is also essential for the study of ultrarelativistic heavy–ion collisions. In fact, during the hadronic phase of the system expansion, the charm hadrons can interact with the other particles produced in the collision, mainly light-flavor hadrons, via elastic and inelastic processes. These interactions modify the heavy-ion observables, and to disentangle this effect from the signatures of the quark–gluon plasma formation, the scattering parameters of the charm hadrons with light-flavor hadrons are required.

This contribution presents the first experimental study of the final-state strong interaction between open-charm and light-flavor mesons. The measurement is performed using the femtoscopy method applied to high-multiplicity proton-proton collisions at $\sqrt{s}$ = 13 TeV, collected by the ALICE Collaboration. The Dπ and D$^*\pi$ scattering lengths are also determined for the first time.

Session 8 / **63**

Outlook and BEACH 2026

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Session 5 / **64**

Charm physics: theory

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Hyperon Physics at Jefferson Lab

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Hyperons play important role in the study of non-perturbative Quantum Chromodynamics. Hyperon-nucleon scattering experiments and hypernuclear spectroscopy provide much needed experimental constraints on poorly known low-energy parameters of the hyperon-nucleon interaction, such as scattering lengths, that are needed in the calculations of the properties of neutron stars. Measurements of properties of strange baryons, such as masses, widths, and line shapes allow to test lattice QCD and QCD-based calculations and to advance the current understanding of the dynamics of confinement. In this presentation we will give an overview key hyperon-nucleon and hyperon spectroscopy programs carried out at the Thomas Jefferson National Accelerator Facility. We will highlight recent results and discuss future perspectives.