Joint International Workshop on Hadron Structure and Spectroscopy (IWHSS 2025) and the QCD Structure of the Nucleon (QCD-N'25)

Monday 1 September 2025 - Friday 5 September 2025

Centro Carlos Santamaría

Book of Abstracts

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Friday / **2**

A General Method for Multiquark Wavefunctions Using Representations of S_n

Authors: Edward Shuryak[None]; Nicholas Miesch[None]

The construction of wavefunctions of multiquark hadrons that obey Fermi statistics can be difficult due to the ways that many particle spin-tensors mix symmetry across sectors. In our recent paper, we have developed technique to find these wavefunctions for color, spin, flavor, and angular coordinates using the correspondence between representations of SU(2) or SU(3) and representations of the symmetry group S_n that works for any number n of indistinguishable particles. In the paper we give hexaquark, pentaquark, as well as some higher quark count wavefunctions for many combinations of spin and flavor. The technique also works for finding wavefunctions of higher angular momentum, at both $L = 1$ and $L = 2$ as shown in another paper which focused on D-shell baryons. We are currently working on studying the pentaquark wavefunctions more closely, and their relation to baryon structure.

Monday / **3**

The perturbative QCD study of the fine structure of pion

Author: Shan Cheng[1]

[1] *Hunan University, China*

We propose to introduce the intrinsic transversal momentum distribution functions (iTMDs), in conjunction with the light-cone distribution amplitudes, to elucidate the probability amplitude of encountering a meson state wherein the partons swiftly traverse along the longitudinal axis while gently oscillating in the transversal plane. The primary motivation stems from the oversight of soft transverse dynamics within the kT factorization formalism of an exclusive QCD process, which confines perturbative QCD (pQCD) predictions to scenarios involving large-momentum transfers.

Thursday / **5**

One-loop renormalization of quark TMD in the light-cone gauge: Collins-Soper-Sterman evolution

Authors: Jamal Jalilian-Marian[None]; Tolga Altinoluk[None]; Guillaume Beuf[None]

We calculate the one-loop corrections to the quark TMD in the light-cone gauge using the background field formalism, with the Mandelstam-Leibbrandt (ML) prescription for the extra singularity present in the light-cone gauge propagator. We use the pure rapidity regulator for rapidity divergences. The Collins-Soper-Sterman (CSS) evolution equations are obtained from the one loop renormalization of the quark TMD.

Tuesday / **6**

Generalized parton distributions from lattice QCD

Author: Hervé Dutrieux[1]

Co-authors: Christopher Monahan ; Joseph Karpie ; Kostas Orginos [2]; Savvas ZAFEIROPOULOS

[1] *CPT Marseille*

[2] *William and Mary - Jlab*

I will present the progress of the Hadstruc collaboration on elucidating the 3D structure of the proton with generalized parton distributions (GPDs) from the pseudo-distribution approach on the lattice. I will particularly devote attention to the uncertainty propagation in the inverse problem faced by concurring approaches on the lattice, and the various lattice systematic uncertainties.

Monday / **7**

News and perspectives from BES-III experiment

Author: Francesco Rosini[None]

Since 2009, the BESIII experiment jas been collecting e^+e^- physics data in the energy range between 2.0 up to 4.9 GeV. This allowed the BESIII Collaboration to cllect the largest datasets of charmonium J/ψ, $\psi(2S)$ and $\psi(3770)$. In particular, the radiative decay of the J/ψ provide a promising hunting ground for glueballs, of which the $X(2370)$ represets a promising candidate. Moreover, the studies of hadron production have lead to the obseravion of SU(3)–flavor breaking effects and rare decay modes of $\psi(3770)$ and $\psi(4160)$ resonances.

Looking at the future, the inner drift chamber has been replaced by a three-layer cylindrical GEM inner tracker (CGEM-IT), achieving ⊠200 μm spatial resolution and ≥95 % layer efficiency, to secure high-precision tracking. Morover, BESIII will triple its current luminoisity and in 2028 the beam energy will rise up to 5.6 GeV in order to explore the direct production of charmed baryons.

Thursday / **8**

Longitudinal Spin Transfer to Λ Hyperons in Semi-Inclusive Deep Inelastic Scattering with CLAS12

Authors: Anselm Vossen[None]; Matthew McEneaney[None]

The polarization of Λ hyperons is preserved in the angular distribution of their decay products. This property allows one to study the spin structure of the Λ. In Semi-Inclusive Deep Inelastic Scattering where a high energy lepton interacts with a nucleon target and one or more hadrons and the scattered lepton are detected in the final state, the probability for a struck quark to impart the polarization of the lepton to the Λ may be measured. In particular, in electron-proton scattering this quantity may be related to the longitudinal light quark polarization of the Λ. Currently, limited experimental data cannot discriminate between different models of Λ spin structure. This work reports on the measurement of the longitudinal spin transfer $D_{LL'}^{\Lambda}$ to the Λ using data taken by the CLAS12 spectrometer at Jefferson Lab with a 10.6 GeV longitudinally polarized electron beam and an unpolarized hydrogen target. This measurement is the most precise to date, and, in comparison with theory predictions, it offers valuable insight into the relative dominance of current and target fragmentation in Λ production.

Thursday / **9**

Dihadron Spin Asymmetries at CLAS12

Author: Gregory Matousek[1]

[1] *Duke University*

Spin asymmetries in semi-inclusive dihadron production have been measured at CLAS12 in several channels. These analyses provide the most comprehensive catalog of dihadron fragmentation to date, exploring novel fragmentation phenomena stemming from the interferences of s- and p-wave dihadron production. First measurements of $\pi^{\pm}\pi^{0}$ beam-spin asymmetries show non-zero signals in structure functions sensitive to $e(x)$, a collinear subleading-twist PDF that is under-explored. This provides a new avenue for the point-by-point extraction of $e(x)$, which encodes quark-gluon correlations within the nucleon. Crucially, our asymmetries provide the first evidence of a significant isospin-dependence in the helicity dihadron fragmentation function $G_1^{\perp}$, revealing its previously unobserved and non-trivial sensitivity to the specific pion pair reconstructed (e.g., $\pi^{+}\pi^{-}$ vs. $\pi^{+}\pi^{0}$). Notably, asymmetries sensitive to $G_1^{\perp}$ exhibit enhancements due to vector meson decays, a property we compare against theoretical frameworks such as the spectator model.

Tuesday / **10**

The nonlocal vector current and its relation to the trace anomaly

Authors: Alessio Carmelo Alvaro[1]; Andreas Metz[None]; Barbara Pasquini[2]; Ignacio Castelli[None]; Simone Rodini[None]

[1] *University of Pavia*

[2] *University of Pavia and INFN-Pavia*

It is a well established fact the connection between the unpolarized GPDs and the energy-momentum tensor. In fact, these GPDs provide access to the gravitational form factors and, consequently, to the trace of the energy-momentum tensor and its anomaly. With this talk, we will show new perturbative results regarding the matrix element of the vector current for on-shell gluons and establish its relation to the energy-momentum tensor and its trace. We also elaborate on the relation of our study to recent discussions about potential anomaly contributions in deeply virtual Compton scattering

Monday / **11**

Pion Transverse Charge Density from Logarithmic Dispersion Relations

Author: Pablo Sanchez Puertas[1]

Co-authors: Christian Weiss [2]; Enrique Ruiz Arriola [3]

[1] *University of Granada*

[2] *JLAB*

[3] *UGR*

The internal structure of charged mesons can be probed through their electromagnetic form factors, which are rigorously connected to the transverse charge density via a two-dimensional Fourier transform. In this talk, we present a dispersive analysis of the timelike electromagnetic form factor of the charged pion, based on a logarithmic dispersion relation applied to the precise $e^{+}e^{-} \to \pi^{+}\pi^{-}$ data up to 3 GeV. This approach enables a model-independent extraction of both the modulus and phase of the form factor, circumventing the difficulties of standard unitarity-based methods above the elastic region.

Our method yields an extraction of the transverse charge density at the percent-level accuracy for distances b
$gtrsim0.1$ fm. At shorter distances, where pQCD effects become relevant, we explore the implications of different high-energy assumptions through sum rules. These tests provide critical information about the onset of pQCD dynamics in exclusive processes and the expected double-logarithmic behavior of the density at small distances.

Thursday / **12**

A new determination of di-hadron fragmentation functions, from e^+e^- BELLE data at $\sqrt{S} = 10.58$ GeV.

Author: Luca Polano[None]

Di-hadron fragmentation functions provide an alternative method for extracting the transversity parton distribution function, complementary to the Collins effect. This method relies on a spin asymmetry in which the denominator involves the unpolarized contribution to di-hadron production. However, measurements of unpolarized inclusive cross sections for charged di-hadron production have only recently become available. In this presentation, I will discuss a new extraction of the unpolarized di-hadron fragmentation functions up to NNLO accuracy, performed in collaboration with Paris-Saclay, and based on both a physics-informed and a neural network parametrization.

Wednesday / **13**

COMPASS and HERMES contributions to polarized TMDs

Author: Filippo Delcarro[1]

[1] *Università di Pavia (IT)*

TMD Sivers distribution is a fundamental tool to investigate the relation between nucleon spin and orbital angular momentum. We present an updated determination of this function, with the inclusion of recent mesurements from COMPASS and Hermes.

Thursday / **16**

Hadronization Research at Belle II

Authors: Katherine Parham[None]; Steven Robertson[1]

[1] *IPP / University of Alberta*

The Belle II experiment continues the research of its predecessors, Belle and BABAR, with the help of the newly upgraded SuperKEKB, the first so-called super B-factory. Electron-positron annihilation experiments provide an exceptionally clean environment in which to study QCD in hadronization into light mesons. Current research in this direction includes the first kaon inclusive DiFF extractions via the jet axis, jet fragmentation studies, and g-2 corrections. These measurements will be crucial to unlocking the full science potential of ongoing and upcoming nucleon scattering experiments at both the Thomas Jefferson National Accelerator Facility (JLab) and the Electron Ion Collider (EIC).

Tuesday / **17**

Production of two pairs of heavy quarks at NLO in collinear factorisation at the LHC and the EIC

Author: Allencris John Rubesh Rajan[1]

[1] *IJCLab and University College Dublin*

We present the first next-to-leading order (NLO) predictions for the associated production of two pairs of heavy quarks through single-parton scattering (SPS) in collinear factorisation in proton-proton collisions at the LHC and photoproduction at the EIC. At the LHC, this process competes with double parton scattering (DPS) contributions to the same final state. A precise calculation of the SPS component is thus essential for improving the extraction and interpretation of DPS studies. The computation is performed within the MadGraph5_aMC@NLO framework, and we provide parton-level differential cross sections, with a particular focus on kinematic correlations in pair azimuthal angles, pair invariant masses, and rapidity differences between heavy quarks.

Thursday / **21**

fragmentation function measurements at B factories

Author: Ralf Seidl[None]

Fragmentation functions describe the formation of confined hadrons from asymptotically-free, high-energetic partons. As they cannot be obtained from first principle calculations in QCD, they need to be extracted experimentally. Especially electron-positron annihilation is a process where they can be cleanly extracted due to the absence of hadrons in the initial state. However, also in other processes fragmentation functions can be accessed, such as semi-inclusive DIS or hadron-hadron collisions.
The recent measurements at B factories and plans from the sPHENIX experiment will be discussed.

Monday / **22**

Light-meson spectroscopy with GlueX and beyond

Author: Alexander Austregesilo[1]

[1] *Jefferson Lab*

The GlueX experiment at Jefferson Lab was specifically designed for precision studies of the light-meson spectrum. A photon beam with energies of up to 12 GeV is directed onto a liquid hydrogen target contained within a hermetic detector with near-complete neutral and charged particle coverage. Linear polarization of the photon beam with a maximum around 9 GeV provides additional information about the production process. In 2018, the experiment completed its first phase, recording data with a total integrated luminosity above 400 pb^{-1} . We will highlight a selection of results from this world-leading data set with emphasis on the search for light hybrid mesons. In the mean time, the detector underwent significant upgrades and is currently recording data with an even higher luminosity. The future plans of the GlueX experiment to search for exotic hadrons with unprecedented precision will be summarized.

Monday / **23**

Understanding photoproduction of ηπ and η'π in the double Regge region

Author: Gloria Montana[1]

Co-authors: Adam Szczepaniak [2]; Vincent Mathieu [3]

[1] *Jefferson Lab*

[2] *Indiana University*

[3] *University of Barcelona*

The existence of hybrid mesons, in which an excited gluonic field contributes to the meson properties, is strongly supported by both theory and experiment. The best experimental candidate for the lightest hybrid meson is the spin-exotic π1(1600), observed in pion production at the COMPASS experiment via its decay into ηπ and η'π. Searching for this state in photoproduction is one of the main goals of the GlueX experiment at Jefferson Lab. Understanding the dynamics and backgrounds is essential for isolating the π1(1600) signal. In the production of ηπ and η'π at high energies, the double-Regge mechanism effectively describes the COMPASS data above the resonance region, including the observed forward-backward asymmetry. In this talk, I present a double-Regge model for ηπ and η'π photoproduction recently developed by JPAC. The model is based on a double-vector exchange with coupling parameters fixed entirely by experimental data, and the reggeization is performed with proper attention to the analytic structure of the amplitude. I will show predictions for cross sections and asymmetries, which will be tested against upcoming GlueX data.

Thursday / **24**

Partonic structure of hadrons & TMD factorization beyond leading power

Author: Leonard Gamberg[1]

[1] *Penn State University Berks*

Abstract:
We present recent work on the transverse momentum dependence of hadrons in semi-inclusive deep inelastic scattering, based on the two complementary factorization frameworks applicable at low and high transverse momentum. These approaches offer critical insight into the partonic structure of the nucleon. Focusing on observables such as the $\cos\phi$ azimuthal modulation, we explore the challenge of matching theoretical descriptions in the intermediate region, which motivates the study of transverse momentum dependent (TMD) factorization at next-to-leading power (NLP). While leading-power TMD factorization is well established, its NLP extension presents significant theoretical and technical challenges. Recent experimental results from COMPASS and Jefferson Lab have begun to shed light on sub-leading TMD effects. Advancing NLP factorization is essential for 3D hadron imaging in current and future DIS experiments, and
for global analyses in the EIC era. We also present preliminary studies of R-SIDIS at large transverse momentum for EIC kinematics. Such measurements can provide new constraints on the gluon parton distribution at large Bjorken-x.

Monday / **25**

Probing the Pion Structure Beyond the Valence Sector in Light-Front Dynamics

Authors: Asmita Mukherjee[1]; Poonam Choudhary[1]; Ravi Singh[1]

[1] *Indian Institute of Technology Bombay, India*

In this talk, we present an ongoing study of the internal structure of the pion using light-front dynamics, going beyond the leading Fock state approximation. We construct light-front wave functions (LFWFs) for the pion that include both quark–antiquark and quark–antiquark–gluon components. This allows us to capture more of the non-perturbative dynamics of the pion and go beyond simple valence-level descriptions. Utilizing these LFWFs, we compute a broad set of parton distributions such as parton distribution functions (PDFs), Form factors, Generalized parton distributions (GPDs) and Gravitational form factors. These observables provide detailed information about the momentum, spatial, and mechanical structure of the pion, revealing how partons are distributed and correlated inside the hadron. These studies are carried out within different light-front based models and help us understand how the results evolve when contributions beyond the valence sector are included. Our results contributes to the broader effort to explore the multidimensional structure of the pion and offers theoretical input for current and upcoming experimental programs at Jefferson Lab, COMPASS, and the Electron-Ion Collider.

Tuesday / **27**

Lepton and heavy-quark pair production in UPCs as a probe of photon GTMDs

Author: Cristian Pisano[None]

Co-authors: Daniel Boer ; Luca MAXIA [1]

[1] *LPTHE - CNRS*

In this talk I will discuss azimuthal modulations in lepton and heavy-quark pair production in ultra-peripheral collisions (UPCs) of highly charged ions. A full description of the cross section in terms of Generalized Transverse Momentum Dependent parton distributions (GTMDs) for photons is given including a consideration of the Fourier transform to impact parameter space. In particular, this leads to a feed-in mechanism among harmonics of different orders, which in principle generates harmonics of all (even) orders. We show that the normalized differential cross section changes considerably with the produced particle mass, which should be discernible in UPCs at RHIC and LHC. For the numerical results we adopt several models for the photon GTMD correlator, and find that all of them are in fairly good agreement with each other and with UPC data from STAR. We also present results for various azimuthal modulations for RHIC kinematics and compare e^+e^- production with the production of heavier particles. These results exhibit interesting mass-dependent features in the asymmetries that may help study the anisotropies arising from the underlying photon GTMD description.

Monday / **28**

Molecular-type hidden charm pentaquarks with an improved unitarization method

Author: Volodymyr Magas[1]

Co-authors: Erick Garcia Gonzales [1]; Àngels Ramos [2]

[1] *University of Barcelona, Spain*

[2] *University of Barcelona*

The existence of the nucleonic pentaquark resonances $P_{c\bar{c}}(4312)^+$, $P_{c\bar{c}}(4380)^+$, $P_{c\bar{c}}(4440)^+$, $P_{c\bar{c}}(4457)^+$, $P_{c\bar{c}s}(4338)^0$ and $P_{c\bar{c}s}(4459)^0$, established by the LHCb collaboration, has been one of the major discoveries in hadron physics in the latest years. Most of these states (5 out of 6) can be understood as hadronic molecules, namely bound states of a sufficiently attractive meson-baryon interaction.

By unitarizing the scattering amplitude in the t-channel vector-meson exchange interaction model one can investigate the dynamically generated resonances. In the recent works [1,2] we revisited the procedure of the unitarized coupled-channel hidden gauge formalism, which has been a very successful approach in explaining many exotic hadrons in the charm and hidden charm sectors. Employing realistic regularization parameters, we predicted two double strangeness pentaquarks of molecular nature. Now we go further and propose an improved unitarization method. The unitarization procedure requires the regularization of the meson-baryon loop function, commonly done using either a cut-off (G^{CO}) or dimensional regularization (G^{DR}). Although both schemes should yield similar results, some unphysical structures in the T-matrix were found that could not be associated to any resonance or bound state. In [3] we introduce a novel hybrid loop function (G^{HY}), which combines both dimensional and cut-off regularizations. This approach enables a cleaner analysis of the scattering amplitude by avoiding the generation of unphysical poles, while keeping the properties of the dynamically generated states unaltered. In particular, this improved procedure allows us to predict two new pentaquark states in the $S = -1$, $I = 1$ sector [3,4].

These recently predicted molecular-type pentaquarks (two in $S = -2$, $I = 1/2$ and two in $S = -1$, $I = 1$) are dynamically generated in a very specific and unique way, via a strong non-diagonal attraction between the two heaviest meson-baryon channels [1,2]. This effect was overlooked before because other research groups were discouraged by the repulsive character of the diagonal kernel coefficients. Moreover, it is also possible that the complex structure of the scattering amplitudes obtained with both G^{DR} and G^{CO} - with unphysical structures - has obscured the physical states [3,4]. If that is the case, the hybrid loop function proposed in [3,4] proves very valuable as it simplifies the scattering amplitudes by only preserving the physical poles.

We hope that our work would stimulate experiments looking for these new pentaquark states, the discovery of which would enrich the family of observed exotic baryons.

1 J.A. Marsé-Valera, V.K. Magas and A. Ramos, Phys. Rev. Lett. 130 (2023) no.9, 9.

2 J.A. Marsé-Valera, V.K. Magas and A. Ramos, Phys. Rev. D 111 (2025) no.5, 5.

[3] E.E. Garcia Gonzales, Master Thesis, July 2025, U. of Sevilla & U. of Barcelona.

[4] E.E. Garcia Gonzales, V.K. Magas and A. Ramos, in preparation for publication.

Thursday / 29

Fragmentation Function Measurements at BESIII

Author: Xiao-Rui Lyu[1]

[1] *University of Chinese Academy of Sciences*

Fragmentation Function (FF) plays a crucial role in describing the hadronization process. In this talk, we report the measurements of normalized differential cross sections of inclusive hadron production as a function of hadron momentum with q^2 transfer from 5 to 13 GeV^2 in the e^+e^- annihilations in the BESIII experiment at BEPCII. These results would provide unique information on the FFs in low energy region. In addition, future prospects on the studies of polarized and non-polarized FFs will be discussed.

Friday / 30

LHCspin: a polarized fixed-target experiment at the LHC

Authors: Giuseppe Ciullo[1]; Luciano Libero Pappalardo[2]; Marco Santimaria[3]; Paolo Lenisa[2]; Pasquale Di Nezza[3]

[1] *Università e INFN, Ferrara (IT)*

[2] *Universita e INFN, Ferrara (IT)*

[3] *INFN e Laboratori Nazionali di Frascati (IT)*

A polarized gaseous target, operated in combination with the high-energy and high-intensity LHC beams, has the potential to open new physics frontiers and to deepen our understanding of the strong interaction at the scale of confinement. Specifically, the LHCspin project aims to perform spin-physics studies in high-energy polarized fixed-target collisions using the LHCb detector. Being designed and optimized for the detection of heavy hadrons, LHCb will allow to probe the nucleon structure through, e.g., inclusive production of c- and b-hadrons, an ideal tool to access the essentially unknown spin-dependent gluon TMDs. This configuration will allow to explore the nucleon internal dynamics at unique kinematic conditions, including the poorly explored high x-Bjorken and high x-Feynman regimes. With the installation of the proposed setup, LHCb will become the first experiment delivering simultaneously unpolarized beam-beam collisions at 14 TeV and both polarized and unpolarized beam-target collisions at center-of-mass energies of the order of 100 GeV. The status of the LHCspin project is presented along with a selection of physics opportunities.

Thursday / 31

Kinematic power corrections in TMD factorization

Authors: Alexey Vladimirov[1]; Sara Piloñeta Álvarez[None]

[1] *Universidad Complutense de Madrid*

In this talk, I present a study of Drell-Yan (DY) and semi-inclusive deep inelastic scattering (SIDIS) structure functions within the framework of the transverse momentum dependent (TMD) factorization theorem, including kinematic power corrections (KPCs). This formalism enables us to describe parts of the cross-section that were previously inaccessible to theory in a Lorentz-invariant manner using only twist-two TMD distributions. Applications include Drell-Yan (DY) angular distributions, the Lam-Tung relation, and the subleading structure functions $F_{UU,T}$ and $F_{UU,L}$. I also discuss the potential impact of these corrections on current and future SIDIS measurements.

Monday / 32

Hadron Cross Sections and Uncertainties in Cosmic Antiproton Production & Beyond

Author: Jennifer Rittenhouse West[None]

Collider-based QCD calculations shed light on cosmic ray antiproton anomalies with novel cross-disciplinary results. Current astrophysical observations require a precise calculation of cross sections for direct proton-proton to antiproton production vs. indirect production (in which the protons first produce an antineutron that decays down to an antiproton with branching ratio 1). The results of cross section and uncertainty calculations using two distinct sets of fragmentation functions for both 17.2 and 8000 GeV center-of-mass energies include finding a discrepancy between the claimed ˜30% difference in direct and indirect antiproton productions. Implications of this work on long-standing baryon/antibaryon yield puzzles will be discussed.

Wednesday / **33**

New insights on flavor dependence in proton and pion TMD extractions

Author: Lorenzo Rossi[1]

[1] *University of Milan & INFN*

In this talk, we present the latest results from the MAP Collaboration on the extraction of unpolarized quark Transverse-Momentum-Dependent Parton Distribution Functions (TMD PDFs) in the proton and pion, as well as Fragmentation Functions (TMD FFs), obtained through global fits to all available data sets. In particular, we highlight the impact of introducing flavor dependence in the nonperturbative components of the TMD models.

Friday / **34**

Nuclear dependence of Drell-Yan Cross Section at Fermilab's E906 experiment

Authors: Harsha Arachchige[1]; S.F. Pate[1]

[1] *New Mexico State University*

Understanding the partonic energy loss in cold nuclear matter is crucial for a better interpretation of observations in future EIC experiments as well as the hot nuclear matter in high-energy collisions such as in LHC. Thus, the topic has received a lot of attention from the community over the past few decades. A clean probe to study the energy loss of partons in cold nuclear mater is nuclear dependence of the Drell-Yan (DY) cross section. A series of p-A DY experiments were conducted at Fermilab to separate the effects of shadowing from the energy loss; E772 ($\sqrt{s} \approx 39$ GeV, $0.04 < x_T < 0.30$), E866 ($\sqrt{s} \approx 39$ GeV, $0.01 < x_T < 0.12$) and E906 ($\sqrt{s} \approx 15$ GeV, $0.1 < x_T < 0.45$). The E906 (SeaQuest) experiment studied the DY production of dimuons by scattering a 120 GeV proton beam off fixed liquid H_2, D_2 and solid Fe, C, W targets. The data set collected provides an opportunity to study the nuclear dependence of the DY cross section and to separate shadowing effects from energy loss, by utilizing a lower beam energy in contrast to the predecessor experiments. The E906 Collaboration has extracted the DY cross-section ratios (CSRs) ($\frac{2}{A}\frac{\sigma_{pA}}{\sigma_{pd}}$) for Fe/D, C/D, and W/D and in this talk we will present the status of this analysis. The potential for the interesting physics that we planned to reveal will be discussed.

This work was supported in part by US DOE grant DE-FG02-94ER40847.

Thursday / **35**

Quark-gluon-quark interference within proton

Author: Alexey Vladimirov[None]

I present the first determination of twist-three distributions, which parametrize the parton interference within hadrons. The determination is based on the global analyses that unify principally different processes such as DIS, single- and double-spin asymmetry, and lattice computations. This opens avenue for multiple novel studies and applications.

Monday / **36**

Investigating $\eta\pi^-$ and $\eta'\pi^-$ Final States in the Double-Regge Region at COMPASS

Author: Henri Clemens Pekeler[1]

[1] *University of Bonn (DE)*

The COMPASS experiment at the CERN SPS provides a high-statistics dataset for studying the light-meson spectrum in various final states, including $\eta\pi^-$ and $\eta'\pi^-$, which are among the key channels to investigate the lightest hybrid-meson candidate, the $\pi_1(1600)$. A major challenge in extracting resonance parameters, such as pole positions, is the separation of resonant and non-resonant contributions.

To better constrain the non-resonant production mechanism in these channels, we analyze the high-mass region ($2.4\,\mathrm{GeV}/c^2 < m_{\eta^{(\prime)}\pi^-} < 6\,\mathrm{GeV}/c^2$) using the double-Regge exchange model developed by the JPAC collaboration. By performing an event-based likelihood fit to the full COMPASS dataset, we test and extend the model to higher invariant masses. We find that, by including form factors to account for the correct t-dependence at the top and bottom vertices, the data can be well described with only 13 free parameters. The relative strengths of the contributing amplitudes in both final states will be presented.

Supported by BMBF.

Wednesday / **37**

Partial-wave decomposition of the diffractively produced $\pi^-\pi^+\pi^-\eta$ final state at COMPASS

Author: David Benjamin Spulbeck[1]

[1] *University of Bonn (DE)*

COMPASS, a versatile fixed-target experiment at the CERN SPS, collected data between 2002 and 2022. The physics program of the experiment ranges from nucleon structure studies to the spectroscopy of hadrons. The latter includes the study of light isovector mesons with total spin J, i.e., a_J and π_J, produced through diffractive scattering of a 190 GeV/c π^- beam off a liquid-hydrogen target. Unparalleled data sets of multiparticle exclusive final states containing charged and neutral particles were recorded, providing also unique opportunities to study the spin-exotic meson $\pi_1(1600)$.

We present the first partial-wave decomposition of the $\pi^-\pi^+\pi^-\eta$ final state, which includes a wide range of decay channels, such as $f_1(1285)\pi^-$, $a_2^-(1320)\eta$, and $\rho(770)a_0^-(980)$. Most of these channels are studied for the first time with COMPASS data. The analysis also includes decay channels predicted by theoretical models for the lightest hybrid meson, providing the opportunity to verify the hybrid meson hypothesis of the $\pi_1(1600)$.

Supported by BMBF.

Monday / **38**

Overview of alpha_S extractions

Author: Oleksandr Zenaiev[1]

[1] *Hamburg University*

An overview of recent extractions of the strong coupling constant from various approaches is presented. The current status of these determinations, their uncertainties, and consistency tests are discussed, along with prospects for future improvements.

Wednesday / **39**

Theoretical Progress on Transverse Single-Spin Asymmetries

Author: Marc Schlegel[None]

In this talk recent progress on Next-To-Leading Order calculations within perturbative QCD for Transverse Single-Single Asymmetries in single-inclusive lepton-nucleon collisions is reviewed. Particularly, the focus is on single-inclusive jet and hadron production in ep collisions, but also single-inclusive as well as semi-inclusive photon production is briefly discussed. All results are relevant for the experimental program at a future Electron-Ion Collider.

Thursday / **40**

Three-loop jet function for boosted heavy quarks

Authors: Alberto Martín Clavero[1]; Maximilian Stahlhofen[None]; Robin Brüser[None]; VICENT Mateu[2]

[1] *Universidad de Salamanca*

[2] *University of Salamanca*

Previous studies have shown that certain observables at massless e^+e^- colliders producing primary top quarks can be used to measure the top quark mass with an uncertainty smaller than $\Lambda_{\rm QCD}$. The maximal sensitivity to the top mass is attained in the peak of the distribution, where Effective Field Theories (EFTs) enable the factorization of the differential cross section across different physical scales. The jet function —previously known at two loops—appears as a common ingredient in many factorization theorems, motivating the computation of this matrix element at higher perturbative orders.

In this talk, we will review the basic EFT concepts and the factorization theorem necessary to introduce the jet function. We will outline the workflow of a fixed-order calculation and present our analytic result for the three-loop jet function for boosted heavy quarks. Our result can be used to improve the calibration of the top quark mass parameter in parton-shower Monte Carlo generators and enhances the perturbative accuracy of the jet invariant mass distribution for reconstructed top quarks.

Monday / **41**

A precise α_s determination from the R-improved QCD Static Energy

Authors: José Manuel Mena Valle[1]; PABLO GARCÍA ORTEGA[2]; VICENT Mateu[2]

[1] *Universidad de Salamanca*

[2] *University of Salamanca*

The strong coupling α_s is the most important parameter of Quantum Chromodynamics (QCD) therefore it is essential to determine it with high precision. This work presents an improved approach for extracting α_s comparing the numerical results of lattice QCD simulations to the perturbative expansion of the QCD static energy. We apply R-improvement to its 3-loop fixed-order prediction, enabling the subtraction of the $u = 1/2$ renormalon and the corresponding summation of large logarithms. We also perform resummation of large ultra-soft logs to N^{3}LL accuracy using renormalization group equations. A new and more flexible parametrization of the renormalization scale has been implemented, allowing us to extend perturbation theory to distances of the order of 1 fm. Perturbative uncertities are estimated randomly varying the parameters that specify the renormalization scale. Performing R-evolution in the MSR mass scheme, we show that the extracted value of α_s is strongly correlated to the prediction for the leading renormalon normalization.

Thursday / 42

Double quarkonium production in hadronic collisions at fixed-target experiments

Authors: Carlo Flore[1]; Cristian Pisano[None]

[1] *Università di Cagliari & INFN*

In this talk, we present new results for double quarkonium production in (un)polarized hadronic collisions at fixed-target experiments. Our approach incorporates the transverse momentum dependent factorization in combination with the Color-Singlet Model. We present new analytical expressions for the angular structure of the cross section for the $q\bar{q}$ induced channel, and provide predictions for the unpolarized cross section and transverse single-spin asymmetries for present and future fixed-target experiments at CERN and the LHC.

Wednesday / 43

The Cold QCD program at RHIC

Author: Zilong Chang[1]

[1] *Indiana University*

Understanding the dynamics of quarks and gluons inside nucleons and nuclei is one of the key areas of research in quantum chromodynamics (QCD). The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Lab collides high energy proton and heavy ion beams to explore the structure of free and bound nucleons. As the world's only polarized proton collider, RHIC has provided unique information about the quark and gluon distributions inside the polarized proton. With the continuous production of high-impact and high-precision results over the past two decades, the RHIC spin program has played an essential role in advancing our understanding of QCD. In this talk, I will focus on three major areas of the program: the helicity structure of the proton, the transverse structure of the proton, and the related QCD physics of cold nuclear matter. The impacts of the RHIC cold QCD program on the physics envisioned for the next generation Electron Ion Collider will also be discussed.

Thursday / 44

Simulation of spin effects for baryon production in deep inelastic scattering

Author: Albi Kerbizi[1]

[1] *Lund University*

Recently we have extended the string+3P0 model of polarized string fragmentation to include the production and decay of spin-1/2 baryons by using a quark-diquark model for the baryon and assuming that string breakings can occur via the tunneling of diquark-antidiquark pairs with vacuum quantum numbers. In this talk we present the implementation of the model in the Pythia event generator for DIS, achieved by an extension of the StringSpinner package, and show the obtained simulation results on the Collins effect for baryon production as well as on the spontaneous polarization of hyperons.

Monday / **45**

Exotic Mesons in Hadro and Photoproduction

Author: Vincent Mathieu[1]

Co-authors: Gloria Montana [2]; Nadine Hammoud

[1] *University of Barcelona*

[2] *Jefferson Lab*

In this talk, I'll review the status of the eta-pi and eta'-pi final in hadroproduction (from the COMPASS collaboration) and in photoproduction (from the GlueX collaboration). We'll discuss the extraction of the resonances properties in their P and D waves (respectively the Pi_1 and A_2 resonances) and how to constraint these extractions using the high mass region (aka the double Regge region) and the finite energy sum rules.

Friday / **46**

SpinQuest: Polarized Target Operation and J/ψ Transverse Single Spin Asymmetry Analysis

Author: Nuwan Chaminda Gunawardhana Waduge[1]

Co-authors: Dustin Keller [1]; Forhad Hossain [1]; Vibodha Bandara [2]

[1] *University of Virginia (US)*

[2] *University of Colombo, Sri Lanka*

The SpinQuest (E1039) experiment at Fermilab is designed to explore the transverse single-spin asymmetry (TSSA), A_N, in J/ψ production involving a transversely polarized solid-state NH_3/ND_3 target and a 120 GeV unpolarized proton beam. The target polarization is achieved using Dynamic Nuclear Polarization (DNP) in a 5 T magnetic field, driven by a 140 GHz Extended Interaction Oscillator (EIO) microwave source. Key components of the target system include a ^{4}He evaporation refrigerator operating at 1 K, a 17,000 m^3/hr roots pump system, and a Q-meter–based NMR setup for continuous polarization monitoring. The system has achieved polarization levels exceeding 90% and has successfully completed commissioning and production runs. Events originating from the target are selected based on the track likelihood from the target origin, and a neural network classifier is used to separate J/ψ signals from combinatorial background, Drell-Yan and ψ' events. The asymmetry is also investigated in low- and high-mass dimuon regions, where contributions from

ψ' and Drell-Yan processes are relevant. These measurements aim to probe gluon-Sivers effects and advance the understanding of transverse momentum–dependent parton dynamics in charmonium production. In this talk I will talk about the DNP process, offline Polarization and the current status of the asymmetry analysis.

Thursday / **48**

New Insights into Lambda Fragmentation Functions

Author: Alessia Bongallino[1]

[1] *Universidad del PaÍs Vasco (UPV/EHU)*

In this talk I present a new determination of the unpolarised fragmentation functions (FFs) for Lambda production from single-inclusive e+e- annihilation and semi-inclusive deep-inelastic scattering. The analysis is done at both next-to-leading order (NLO) and next-to-next-to-leading order (NNLO). We extract the unpolarised FFs defining a parametrisation in terms of a neural network and determine their uncertainties with a Monte Carlo sampling method.

Monday / **49**

Light-Meson Spectroscopy at COMPASS

Author: Julien Beckers[1]

[1] *Technische Universitaet Muenchen (DE)*

COMPASS is a multi-purpose fixed-target experiment at the CERN SPS. One of its main goals is to probe
the strong interaction at low energies by studying the excitation spectrum of light mesons in diffractive scattering reactions of a 190 GeV/c hadron beam on a proton target.
This is done by decomposing the data into partial-wave amplitudes with well-defined quantum numbers and searching for resonances in these amplitudes.

We have collected the world's largest datasets of various final states.
First and foremost, COMPASS' flagship $\pi^-\pi^-\pi^+$ channel has allowed high-precision measurements of many light mesons.
New analyses of final states with kaons complement their findings. After briefly presenting the analysis method, we will discuss measurements in the $\mathrm{K}^0_S\mathrm{K}^-$ final state, which gives access exclusively to a_J mesons at higher invariant masses.

COMPASS has also contributed significantly in the search for exotic (non-$q\bar{q}$) mesons. We will present novel analyses of the $\omega\pi^-\pi^0$ and $\pi^-\pi^-\pi^+\eta$ final states, which are especially interesting as the lightest hybrid meson is predicted to decay into both of these final states.

Taking advantage of the kaon fraction of the beam, the COMPASS analysis of the $\mathrm{K}^-\pi^-\pi^+$ final state has given insight into the lesser known strange-meson spectrum.
These efforts will be continued in the AMBER experiment via
its planned strange-meson spectroscopy programme.

The COMPASS data also allows for measurements beyond spectroscopy. We will discuss one such analysis of the non-resonant double-Regge exchange process, done in collaboration with JPAC.

Tuesday / **50**

Hard Exclusive Meson Production at COMPASS

Author: Kamil Augsten[1]

[1] *Czech Technical University in Prague (CZ)*

We will present recent results from the COMPASS collaboration on hard exclusive muoproduction of mesons using 160 GeV polarized beams scattering off a liquid hydrogen target. The data cover a unique kinematic regime in the intermediate Bjorken-x domain and moderate Q^2, providing new constraints on the nucleon's generalized parton structure. The measurements include cross-section of exclusive π_0 production, which is particularly sensitive to chiral-odd Generalised Parton Distributions (GPDs), and Spin Density Matrix Elements (SDMEs) of light vector mesons, which indicate a violation of s-channel helicity conservation. These observables offer critical input for global GPD fits and open the possibility to access transversity GPDs through a model-dependent interpretation of exclusive vector meson production amplitudes.

Monday / **51**

The Pion Parton Distribution Puzzle in the Valence Region.

Author: Misak Sargsian[1]

[1] *Florida International University*

We discuss recent extraction of parton distribution function of pion in the valence region which observed
unexpectedly soft $(1-x)^{\beta}$, $\beta \sim 1$ distribution, contradicting several theoretical predictions including the ones
based on the hard gluon exchange, according to which $\beta = 2$.
In this work we calculated the pion PDF within the theoretical approach based on spectral function representation
of valence structure in the nucleon.
The approach was first applied for nucleon valence PDF's which demonstrated the existence of pion-cloud structure
in the nucleon already at the starting Q_0 for which initial PDF's are defined. Our calculation also shows substantial high momentum
component in nucleon for large x. Applying the same approach for calculation of pion valence PDF's, we first observe that
no additional residual structure exists in the pion as it was the case for nucleons. Our calculation largely describes the recently obtained
phenomenological PDF's by JAM collaboration. We observe that the Feynman mechanism is responsible for pion PDF at
relatively large x leaving little room for the hard q\bar q interaction at the large x region.

Friday / **52**

Highlights and perspectives from the sPHENIX experiment

Author: Nicole D'Hose[1]

[1] *Université Paris-Saclay (FR)*

The sPHENIX experiment is a new detector at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory. Designed for precision measurements of jet and heavy-flavor observables, sPHENIX provides precision vertexing, tracking, and electromagnetic and hadronic calorimetry in the central pseudorapidity region |eta| < 1.1 with full azimuthal coverage, at the full RHIC collision rate. In addition to measurements of the quark-gluon plasma produced in heavy ion collisions, sPHENIX also enables new and improved measurements in the spin program called cold QCD at RHIC. This talk will describe the status of the analysis of transverse single-spin asymmetries for polarized proton-proton collision at a center-of-mass energy of 200 GeV. These results will provide new information for comparing multi-parton correlations in collinear twist-3 formalism with the transverse-momentum-dependent factorization scheme.

Friday / **53**

Hadron-in-jet production in pp collisions: TMD phenomenology

Author: Umberto D'Alesio[None]

Co-authors: Carlo Flore [1]; Marco Zaccheddu [2]

[1] *Università di Cagliari & INFN*

[2] *Jefferson Lab*

We present a phenomenological analysis of hadron-in-jet production in pp collisions within a TMD approach, employing a collinear configuration for the initial state.

We mainly focus on the Collins azimuthal asymmetries for pion-in-jet production, adopting recent extractions of the transversity and the Collins fragmentation functions (FFs) from SIDIS and e^+e^- processes. The general agreement of our estimates with the available data from the STAR Collaboration corroborates the hypothesis of the TMD factorization for such processes as well as of the universality of the Collins FF.

Similar conclusions, towards a general universality of the TMD FFs, can be drawn from a complementary study of the transverse polarization of Λ hyperons produced within a jet in unpolarized pp collisions.

Open issues and future improvements, on both the experimental and the theoretical side, are also discussed.

Friday / **58**

Measurement of neutral meson transverse single-spin asymmetry in polarized pp collisions at sPHENIX

Author: Virgile Mahaut[1]

[1] *CEA Saclay*

The sPHENIX experiment is a next-generation collider detector at the Relativistic Heavy Ion Collider (RHIC). The experiment includes a large acceptance, granular electromagnetic calorimeter and very high rate data acquisition plus trigger system. In the RHIC Run-2024, sPHENIX collected data from the collisions of transversely polarized protons at $\sqrt{s}$ = 200 GeV using calorimeter-based, high-energy jet and photon triggers. This talk describes the extraction of transverse single-spin asymmetries in inclusive forward production of $\pi 0$- and η-mesons decaying into two photons, the first transverse single-spin asymmetry extracted from sPHENIX data. Such observables are sensitive to multi-parton correlations in the proton, which are related to transverse-momentum dependent (TMD) effects. The

results are reported for meson transverse momenta between 3 GeV and 10 GeV (3 GeV and 20 GeV) for the $\pi 0$ (η) meson and are compared to PHENIX RHIC Run-2015 data.

Tuesday / **59**

Hard Exclusive pi0 Meson Electroproduction

Author: Valery Kubarovsky[None]

Exclusive electron scattering reactions at high momentum transfers are directly related to the Generalized Parton Distributions (GPDs) of quarks and gluons. Examples include electron elastic scattering, deeply virtual Compton scattering (DVCS), and deeply virtual meson electroproduction (DVMP). Most reactions studied, such as DVCS and vector meson electroproduction, are primarily sensitive to chiral-even GPDs. However, pseudoscalar meson electroproduction, particularly the production of pi0 and eta mesons, has been identified as especially sensitive to parton helicity-flip subprocesses. Dedicated experiments to study deeply virtual meson production have been conducted at Jefferson Lab. A comparison of these experimental results with theoretical models will be presented, along with a discussion on the extraction of transversity GPD parameters through a global fit of the available data.

Tuesday / **60**

Overview of Generalized Parton Distributions (GPDs)

Author: Jianwei Qiu[1]

[1] *Jefferson Lab*

Generalized Parton Distributions (GPDs) are fundamental quantum correlation functions of quarks and gluons (collectively referred to as partons) inside hadrons and encode rich information that can unravel many aspects of the confined hadron structure, such as quark and gluon tomography, as well as emergent hadronic properties, including the mechanical properties and spin and mass decompositions. In this presentation, I will give a brief overview on the theory and phenomenology of GPDs, as well as physical processes that are sensitive to GPDs. I will concentrate on the extraction of GPDs from experimental observables, especially on the challenges and potential solutions regarding the separation of different GPDs and the extraction of x-dependence of GPDs, which is critically important for constructing the tomographic images of hadrons and for matching the x-moments of GPDs to various emergent hadron properties.

Tuesday / **61**

Jefferson Lab: Present and Future

Author: Patrizia Rossi[1]

[1] *Jefferson Lab*

Jefferson Lab's Continuous Electron Beam Accelerator Facility (CEBAF) continues to be a global hub for nuclear physics research, with a very strong and specific focus on hadron physics. This presentation will highlight selected key achievements from the 12 GeV CEBAF program, which provides a unique window into the fundamental structure of matter.
Looking to the future, I will outline the exciting plans to expand Jefferson Lab's scientific capabilities. These include a potential energy upgrade to 22 GeV to push the kinematic boundaries of our

experiments, and the development of a high-quality positron beam. An initial investigation of potential secondary beams of muons and neutrinos produced by the interaction of the Jefferson Lab 11 GeV intense electron beam with the experimental Hall-A beam dump has also started. These new capabilities would enable a host of new physics opportunities, from the exploration of nucleon structure with unprecedented precision to precision tests of the Standard Model. The talk will provide an overview of the facility's current progress and its ambitious vision for the next generation of physics research.

Tuesday / **62**

COMPASS GPD Programme

Author: Po-Ju Lin[1]

[1] *National Central University (TW)*

Correlating the transverse spatial distribution of a parton to its longitudinal momentum, Generalized Parton Distributions (GPDs) provide a partonic structure description of a hadron beyond one dimension, and give the possibility to unveil interesting details regarding various properties of the hadron. The GPD program at COMPASS experiment utilized polarized muon beams at 160 GeV on the unpolarized proton target, and has been providing useful inputs for GPD study with measurements of deeply virtual Compton scattering and hard exclusive production of a variety of mesons. In this talk, these exclusive measurements will be introduced and some recent progresses will be presented.

Wednesday / **63**

Overview of the Jefferson Lab Hall C SIDIS Experimental Program

Author: Edward Kinney[None]

A new era of Semi-Inclusive Deep Inelastic Scattering (SIDIS) experiments at Jefferson Lab's Hall C began in 2018 after the commissioning of the new Super High Momentum Spectrometer (SHMS), and using the upgraded 11 GeV intense CW electron beam. Combined with the existing High Momentum Spectrometer (HMS), one can now perform SIDIS measurements on liquid Hydrogen and Deuterium as well as a variety of solid targets. The use of small acceptance focusing spectrometers and high luminosity allows the precise determination of very small cross sections. In particular it allows one to map out the SIDIS reaction, with high statistical accuracy, with respect to any of the variables x, Q^2, z, p_T, and ϕ^* while keeping the other variables fixed.
First experiments focused on measurements of charged pion SIDIS at 10.5 GeV exploring the p_T and ϕ^* dependence as well as a study of charge symmetry breaking. In 2023 the SHMS carriage was used to hold a new high-resolution EM calorimeter, the Neutral Particle Spectrometer (NPS) and data were collected simultaneously on DVCS and neutral pion SIDIS. Since the DVCS experiment required a separation of the longitudinal/transverse (L/T) cross sections, this separation will also be possible for the SIDIS reaction. Finally, in summer 2025, experiments dedicated to determining the L/T charged pion SIDIS ratio from hydrogen, deuterium, carbon and copper have received their first block of running time, and are scheduled to be completed in 2026. Highlights from each of these programs will be presented along with discussion of future plans.

Friday / **64**

SPD project at NICA

Author: Elena Zemlyanichkina[1]

[1] *Joint Institute for Nuclear Research (RU)*

The SPD experiment will operate at one of the two interaction points of the NICA at JINR. The collider will deliver polarised beams for pp and dd collisions with center-of-mass energies up to $\sqrt{s} = 27\,\mathrm{GeV}$ and $\sqrt{s_{NN}} = 13.5\,\mathrm{GeV}$, respectively. The main objective of the experiment is to investigate both polarized and unpolarized gluonic structures of protons and deuterons. Transverse momentum dependent distribution functions related to gluons — including helicity, Sivers, Boer-Mulders distributions, and gluon transversity specifically in deuterons — will be studied using measurements of open charm, charmonium, and prompt photon production. Beyond its core objectives, the experimental program encompasses investigations into diverse facets of Quantum Chromodynamics (QCD). This presentation will provide an overview of the physics program, describe the experimental setup, and discuss the current status of the project.

Wednesday / **66**

Insights into Nucleon Transverse Spin: Recent COMPASS Results from SIDIS

Author: Jan Matousek[1]

[1] *Charles University (CZ)*

COMPASS experiment has collected a large data set on hadron production in deep inelastic scattering (DIS). In particular, in 2022 it collected world-unique data with 6LiD target containing transversely polarised deuterons. DIS is a powerful tool to access parton distribution functions (PDFs) that describe the nucleon structure in the context of inelastic high-energy collisions, including correlations between the parton and nucleon spins and parton transverse momenta. The polarised deuterons are instrumental to access d-quark PDFs. Recent results and the outlook will be presented.

Wednesday / **68**

Transverse spin and momentum: 20 years of progress

Authors: Alessandro Bacchetta[None]; Alessandro Bacchetta[None]

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Friday / **69**

Overview of the SpinQuest Program at Fermilab

Author: Vaniya Ansari[1]

[1] *Aligarh Muslim University*

SpinQuest at Fermilab is a high-luminosity fixed-target experiment aimed at investigating the transverse momentum structure of the nucleon by measuring the Sivers function for light sea quarks and gluons. Using a 120 GeV unpolarized proton beam incident on transversely polarized ammonia (NH_3) and deuterated ammonia (ND_3) targets, the experiment seeks evidence of sea-quark orbital

angular momentum and probes the gluon Sivers function through transverse single-spin asymmetries in J/ψ production. By combining Drell–Yan and quarkonium measurements, SpinQuest offers complementary insights into spin–momentum correlations within the nucleon. The program relies on the polarized target system featuring a 5˜T magnet, 140˜GHz microwave source, and a high-capacity ^{4}He evaporation refrigerator. In this talk, the experiment status from the 2024 commissioning run, ongoing analysis efforts, and preparations for the upcoming 2026 production run will be presented.

This work is supported in part by the U.S. DOE award #:˜DE-FG02-07ER41528

Thursday / **70**

The muon anomalous magnetic moment: is the anomaly still anomalous?

Author: Pere Masjuan[None]

The long-standing discrepancy between the experimental measurement and the Standard Model prediction of the muon anomalous magnetic moment has prompted extensive theoretical and experimental efforts. Recent progress, particularly in lattice QCD and improved data-driven approaches, has led to a reassessment of the hadronic vacuum polarization contribution, reducing—if not eliminating—the tension. In this talk, I will review the current status of the muon g–2, focusing on the interplay between different theoretical evaluations and the latest experimental results. Special attention will be given to the hadronic contributions, including both HVP and hadronic light-by-light scattering, and to the implications of recent QCD-based calculations. I will discuss whether a significant discrepancy remains, and what this means for the prospects of new physics.

Wednesday / **73**

Polarized He3: from HERMES to CLAS

Author: Richard Milner[None]

Polarized He-3 is accepted as an effective polarized neutron for scattering experiments to study hadron structure. The HERMES experiment was commissioned and took first data in 1995 running with a polarized He-3 target. Targets have been in routine use at Jefferson Lab, Mainz and other laboratories. The MIT group has pioneered development of high field optical pumping of He-3 gas for both a polarized ion source for EIC at BNL and polarized target development at CLAS12 at Jefferson Lab.
The status of developments and planned physics will be described.

Monday / **75**

AMBER overview

Author: Thomas Poschl[1]

[1] *CERN*

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Wednesday / **76**

Review of the newest HERA QCD results.

Author: Katarzyna Wichmann[1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

HERA accelerator in Hamburg has been, so far, the only high energy electron-proton collider. Despite the fact that it was shut down in 2017, the HERA collaborations are still analyzing the data and publishing results. In this talk I will show a review of the newest results from the H1 and ZEUS collaboration, including proton structure, strong coupling, jets and other QCD measurements.

Wednesday / **77**

Five Decades of the E-Jaffe Sum Rule

Wednesday / **81**

HERMES - Physics Overview

An overview of 30 years of physics data harvesting at HERMES will be given.

Friday / **88**

SeaQuest

Author: Paul Reimer[None]

Tuesday / **90**

EIC Status and Prospects

Author: Maria Zurek[None]

The Electron-Ion Collider will be a next-generation facility designed to explore the internal structure of nucleons and nuclei with unprecedented precision. By colliding polarized electrons with polarized protons and a range of nuclei across a broad kinematic regime, the EIC will provide access to multi-dimensional probes of nucleon structure, such as TMDs, GPDs, and other partonic correlations. These measurements are crucial for understanding the origin of nucleon spin, mass, and other emergent phenomena in QCD.

In this talk, I will present the current status of the EIC, with a focus on the design and capabilities of ePIC, the general-purpose detector at the EIC. I will also outline the unique physics opportunities enabled by the EIC and discuss how they complement and extend ongoing efforts across the global hadron physics community.

Wednesday / 91

Transverse Momentum Effects in Unpolarized Semi-Inclusive DIS at COMPASS

Author: Vendula Benesova[1]

[1] *Charles University (CZ)*

The azimuthal angle (ϕ_{h}) and transverse momentum squared (P_{T}^2) distributions of charged hadrons produced in semi-inclusive deep inelastic scattering (SIDIS) provide valuable access to the transverse momentum structure of the nucleon. These observables are sensitive to transverse momentum-dependent parton distribution functions (TMD-PDFs) and fragmentation functions (FFs), offering insight into the dynamics of partons inside the nucleon.

The COMPASS Collaboration at CERN collected a high-statistics SIDIS data set in 2016 and 2017 using a longitudinally polarized 160 GeV/c muon beam scattering off a liquid hydrogen target. Measurements of azimuthal asymmetries and P_{T}^2-distributions have been performed using a subset of this data. QED radiative corrections have been applied using the DJANGOH Monte Carlo generator. The impact of these corrections on the unpolarized SIDIS results will be discussed.

Wednesday / 92

HERMES - The early years

Author: Klaus Willi Rith[None]

The early years of HERMES from the first ideas in 1987 until the start of data taking in May 1995 will be reviewed.

Thursday / 93

Spin-transfer to Lambda hyperons in DIS

Author: Denis Veretennikov[1]

Co-author: HERMES Collaboration

[1] *University of the Basque Country UPV/EHU*

The HERMES experiment has collected a wealth of data using the 27.6 GeV longitudinally polarized HERA lepton beam and various polarized and unpolarized gaseous targets. This allows for a series of unique measurements of observables sensitive to the multidimensional (spin) structure of the nucleon, in particular semi-inclusive deep-inelastic scattering (SIDIS) measurements, for which the HERMES dual-radiator ring-imaging Cherenkov counter provided final-hadron identification between 2 GeV to 15 GeV for pions, kaons, and (anti)protons.
Lambda hyperons in the final state give us the unique opportunity to study spin dependent effects through its polarization measurements using its weak decay channel. In this contribution, the longitudinal and transverse component of the spin transfer coefficient from the longitudinally polarized electron/positron beam to the lambda or antilambda hyperon alongside with kinematical dependences on Feyman- and Bjorken-x as well as the hyperon's transverse momentum will be presented. These spin-transfer coefficients provide access to several spin-dependent fragmentation functions, which have been related to the inner structure of Λ hyperons. The results are also compared to similar measurements at the COMPASS and NOMAD experiments.

Monday / **94**

Status of the MUSE experiment

Author: Tigran Rostomyan[1]

[1] *Paul Scherrer Institute*

The MUon proton Scattering Experiment (MUSE) at the Paul Scherrer Institute (PSI) was motivated by the proton radius puzzle. We obtain simultaneous high-precision measurements of elastic electron-proton and muon-proton scattering from a liquid hydrogen target, alternating between positively and negatively charged leptons. The experiment will test lepton universality by comparing electron to muon scattering, will determine two-photon exchange by comparing scattering of positive to negative charged leptons, and will extract the proton charge form factor and radius from the cross sections. The experiment runs at beam momenta of 115, 160, and 210 MeV/c to cover the low-Q2 region of Q2 = 0.002 to 0.082 GeV2 which is maximally sensitive to the proton charge radius. In addition, because the beam includes electrons, muons and pions, we obtain pion-proton elastic scattering data. To date, MUSE has commissioned its experimental systems to the level needed for the measurements and performed a careful studies of the electron and muon beam properties in the PiM1 channel. As of mid 2025, MUSE has obtained nearly 80% of its planned scattering data and will reach its goal in statistics by the end of this year. An overview of the MUSE experiment and current status will be given in this talk.

The MUSE experiment is supported by the US National Science Foundation and Department of Energy, PSI, and the US-Israel Binational Science Foundation.

Wednesday / **95**

The simultaneous global QCD analysis of transverse momentum dependent and collinear parton distributions

Authors: Alexey Prokudin[1]; Alexey Vladimirov[2]; Christopher Cocuzza[None]; Daniel Pitonyak[3]; Eric Moffat[4]; Jianwei Qiu[5]; Leonard Gamberg[6]; Patrick Barry[4]; Trey Anderson[None]; Wally Melnitchouk[5]

[1] *PSU Berks and JLab*

[2] *Universidad Complutense de Madrid*

[3] *Lebanon Valley College*

[4] *Argonne National Lab*

[5] *Jefferson Lab*

[6] *Penn State University Berks*

We present the first global QCD analysis of the collinear and transverse momentum dependent parton distribution functions (PDFs and TMD PDFs) in the proton. Our study incorporates transverse momentum dependent Drell-Yan data from fixed-target and collider experiments, including precise high-energy Drell-Yan and
Z-boson production measurements from the Large Hadron Collider, sensitive to TMD PDFs, as well as data from inclusive deep inelastic scattering experiments, integrated Drell-Yan lepton-pair production, inclusive weak boson, $W+$\,charm, and jet production data sensitive to PDFs.
The analysis is performed at next-to-next-to-leading logarithmic (N2LL) accuracy for QCD resummation and next-to-leading order (NLO) accuracy in the strong coupling for collinear quantities. For the first time, we are able to study and quantify the impact of simultaneous inclusion of both data sets in the global fit. We find that this combined analysis leads to improvements in the knowledge of both TMDs and collinear PDFs.

Friday / **97**

Insights into Nucleon Spin and 3D Structure in the COMPASS Drell-Yan Programme

Author: Malgorzata Rozalia Niemiec[1]

[1] *University of Warsaw (PL)*

Understanding the internal structure of the nucleon remains one of the foremost goals in modern hadron physics. Transverse Momentum Dependent Parton Distribution Functions (TMD PDFs) provide a powerful framework for describing the three-dimensional partonic structure and internal dynamics of the nucleon. Semi-inclusive deep inelastic scattering measurements from HERMES and COMPASS have delivered pioneering insights into TMD PDFs, yet fully addressing their process dependence and testing their universality demands complementary probes.

The Drell-Yan process offers such a probe, with direct sensitivity to initial-state parton distributions and the capacity to test fundamental QCD predictions on TMD universality. In 2015 and 2018, the COMPASS experiment at CERN collected the first-ever polarised Drell-Yan data using a 190 GeV negative pion beam on a transversely polarised ammonia target. Additional unpolarised data were collected with aluminium and tungsten targets.

This presentation will review the legacy of the COMPASS Drell-Yan programme in advancing our understanding of nucleon spin structure, present recent results, and discuss prospects for future TMD studies.

Wednesday / **98**

Transverse Spin at JLab

Author: Marco Contalbrigo[1]

[1] *Universita e INFN, Ferrara (IT)*

In the recent years, it has been realized that deep-inelastic scattering with polarization control could provide a variety of spin and azimuthal angle dependent observables sensitive to the quark-gluon interactions.

New parton distributions and fragmentation functions have been introduced to describe the rich complexity of the hadron structure and move towards a multi-dimensional imaging of the underlying parton correlations. Besides the hard probe scale, these functions explicitly depend on the parton transverse degrees of freedom at the scale of confinement. Their study promises to open a unprecedented gateway to the peculiar nature of the strongly interacting force.

This work presents a selection of available observations and upcoming measurements planned at Jefferson Lab to address the mysteries of the nucleon structure from a modern point of view.

Thursday / **100**

Measurements of hadron pair asymmetries in SIDIS at COMPASS

Author: Anna Martin[1]

[1] *Trieste University and INFN (IT)*

The COMPASS experiment at CERN has studied the three-dimensional structure of nucleons by making unique measurements of several processes. This presentation focuses on measurements of hadron pair production in SIDIS with the 160 GeV muon beam and unpolarized and polarized proton and deuteron targets. The most recent results are reviewed, with particular attention to the measurements of transverse spin asymmetries from data collected in 2022 with the 6LiD target. The impact of these measurements on the extraction of the transversity distribution functions is also discussed.

Wednesday / **101**

HERMES@DESY - the lab's view

Author: Manfred Fleischer[1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

HERMES recorded the first collisions with the HERMES experiment at HERA 30 years ago. This article will examine the host lab's perspective: what was the decision-making process, what were the prerequisites, how was the experiment implemented and operated, and what technical problems remain to be solved even after 30 years.

Tuesday / **102**

DVCS studies with CLAS12

Author: Silvia Niccolai[1]

[1] *CNRS*

Generalized Parton Distributions (GPDs) are nowadays the object of an intense effort of research, in the perspective of understanding nucleon structure. They describe the correlations between the longitudinal momentum and the transverse spatial position of the partons inside the nucleon and they can give access to the contribution of the orbital momentum of the quarks and gluons to the nucleon spin.
Deeply Virtual Compton scattering (DVCS), the electroproduction on the nucleon, at the partonic level, of a real photon, is the process more directly interpretable in terms of GPDs of the nucleon. Depending on the target nucleon (proton or neutron) and on the DVCS observable extracted (cross sections, target- or beam-spin asymmetries, ⋯), different sensitivity to the various GPDs for each quark flavor can be exploited. Gluon GPDs can also be accessed by probing specific kinematic regimes. And, besides DVCS, other exclusive reactions, such as Timelike Compton Scattering, Double DVCS, or the exclusive electroproduction of mesons, can provide information on GPDs.
This talk will provide an overview on recent and new, promising, DVCS-related experimental results, obtained at in Hall B at Jefferson Lab on fixed target experiments with a 12-GeV electron beam, for various target types and final states, using the CLAS12 spectrometer. These data open the way to a "tomographic"representation of the structure of the nucleon, allowing the extraction of transverse space densities of the quarks at fixed longitudinal momentum, as well as paving the way to the quarks'angular momentum contribution to the spin of the proton.

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Pushing the boundaries –birth of SSAs

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Pioneering measurements of Single-Spin Asymmetries (SSAs) at HERMES and COMPASS, followed by high-precision studies at JLab, have been essential for uncovering the rich and extraordinary variety of non-perturbative effects in hadronic structure. Semi-inclusive and exclusive hadron production—both single and dihadron, in current and target fragmentation regions—provides a wide range of spin- and azimuthal-angle–dependent observables, offering unique sensitivity to the dynamics of quark–gluon interactions. Investigations of spin-dependent structure functions and the underlying transverse momentum distributions of partons are now driving upgrades of existing facilities and shaping the design of new ones worldwide.
This talk will highlight the impact of SSA measurements and explore future directions in studies of the 3D hadron structure through electroproduction,

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On the extraction of collinear distributions

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In this contribution, I will give a brief overview of the most common methodologies currently used to extract collinear distributions from experimental data. I will mainly focus on unpolarised parton distribution functions (PDFs), touching upon perturbative ingredients, parameterisations, and data sets. I will also mention recent developments in longitudinally polarised (helicity) PDFs and, if time allows, unpolarised fragmentation functions.

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QCD-N'02 and QCD-N'06

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Pintxo tour

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HERMES ABS

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HERMES Memories

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Closeout

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