# 26th International Symposium on Spin Physics (SPIN2025)

# Report of Contributions

https://indico.ihep.ac.cn/e/spin2025

Contribution ID: **1** Type: **Oral**

# Chiral phase transition and spin alignment of vector mesons with chiral imbalance in a rotating QCD medium

We study the two-flavor Nambu-Jona-Lasinio model under the rotation and chiral chemical potential μ5. First, the influence of chiral imbalance on the chiral phase transition in the Tpc – ω plane is investigated. Research manifests that, as μ5 increases, the critical point of the Tpc – ω plane chiral phase transition will move closer to the T axis. This means that the chiral chemical potential μ5 can significantly affect the Tpc – ω phase diagram and phase transition behavior. While discussing the Tpc – ω phase diagram, we also study the spin alignment of the ρ vector meson under rotation. In the study of the spin alignment of the
vector meson ρ, ρ00 is the 00 element of the spin density matrix of vector mesons. At high temperatures, ρ00 is close to 1/3, which indicates that the spin alignment of the vector meson ρ is isotropic. The study found that, under finite rotation, increasing the chiral chemical potential μ5 can significantly enhance ρ00 around the phase transition temperature. When rotational angular velocity is zero, ρ00 is close to 1/3, but as ω increases, ρ00 significantly decreases and deviates 1=3, indicating that rotation can significantly cause polarization characteristics. The ρ00 – r relationship near the phase transition temperature is studied. It is found that the farther away from the center of rotation, the lower the degree of spin polarization of the system. It is also found that the influence of chiral imbalance on the ρ00 – r relationship is also significant.

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**Presenter:** SHENG-QIN, Feng (College of Mathematics & Physics, Three Gorges University)

**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **2** Type: **Oral**

# Bell Inequality Violation of Light Quarks in Dihadron Pair Production at Lepton Colliders

Spin correlations between particles produced at colliders provide valuable insights for quantum information studies. While traditional studies of quantum information at colliders are typically limited to massive particles with perturbative decay, we propose an innovative method to explore the Bell inequality in massless quark pair systems by analyzing the azimuthal correlations in $\pi^+\pi^-$ dihadron pair production at lepton colliders. Revisiting the Belle data, we have shown the potential to detect Bell inequality violation of light quarks by introducing an additional angular cut, achieving a significance of 2.5 $\sigma$ even in the worst-case scenario of 100\% correlated systematic uncertainties in each bins. The significance substantially exceeds $5\sigma$ when considering uncorrelated systematic uncertainties. Our approach opens avenues for exploring spin quantum information with non-perturbative processes as spin analyzer and leverages existing data for quantum information research.

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**Session Classification:** Parallel

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **3** Type: **Oral**

# Observation of a family of all-charm tetraquarks with spin-2 and positive parity

We present a detailed spin-parity analysis of near-threshold structures in the fully-charm tetraquark sector, using a matrix-element-based approach applied to the J/\psi J/\psi \rightarrow 4\mu final state. Based on the full Run-2 dataset from the CMS experiment, multiple JˆP hypotheses are tested using kinematic distributions of the four-muon system. A set of spin-parity combinations, JˆP = 0ˆ+, 0ˆ-, 1ˆ+, 1ˆ-, 2ˆ+, 2ˆ-, is considered. The primary analysis uses decay-only observables, while production angular distributions are also examined to test consistency with a polarized initial state. The result establishes the quantum numbers C = +1, P = +1, and J = 2 as the most likely configuration, offering strong constraints on the nature of fully-charm tetraquark states. Besides, complementary studies with both Run 2 and Run 3 data based on the J/\psi J/\psi and J/\psi \psi(2S) \rightarrow 4\mu final states were also conducted, revealing consistent spectral structures associated with the observed resonances.

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**Session Classification:** Parallel

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **4** Type: **Oral**

# Lattice calculation of Baryon Light-cone Distribution Amplitudes

We present a lattice QCD calculation for the leading-twist Light-cone Distribution Amplitudes (LCDAs) of the Lambda and Proton, within the framework of Large-momentum Effective Theory (LaMET). The numerical computation employs CLQCD ensembles with stout smeared clover fermions and a Symanzik gauge action. In order to obtain reliable results in both perturbative and non-perturbative regions, we adopt a new Hybrid renormalization scheme and carry out simulations at 4 different lattice spacings: a = {0.052, 0.068, 0.077, 0.105} fm. To access the large momentum regime and facilitate matching to LCDAs, we simulate the quasi-Distribution Amplitudes (quasi-DAs) with hadron momenta Pz around 1˜3 GeV. After renormalization and extrapolation, we present results for the distribution of momentum fractions for the two light quarks in Lambda and Proton.

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**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **5** Type: **Oral**

# First-Principle Calculation of Collins-Soper Kernel from Quasi-Transverse-Momentum-Dependent Wave Functions

We present a lattice QCD calculation of the Collins-Soper kernel, which governs the rapidity evolution of transverse-momentum-dependent (TMD) distributions, using Large Momentum Effective Theory (LaMET). Quasi-TMD wave functions are computed with three meson momenta on CLQCD configurations (multiple lattice spacings) employing clover quarks and varied hadronic states. HYP smearing is applied to staple-shaped gauge links and Wilson loops to enhance signal-to-noise ratios. Divergences are systematically addressed: linear divergences via Wilson-line renormalization and logarithmic divergences through a self-renormalization-inspired scheme.

By combining two-loop light-cone matching, renormalization group evolution, and leading renormalon resummation, we determine the Collins-Soper kernel for transverse separations up to 1 fm, with extrapolation to large-momentum and continuum limits. This work provides critical inputs for soft functions and precision studies of TMD physics, advancing first-principles QCD in high-energy phenomenology.

**Primary author:** TAN, Jin-Xin (Shanghai Jiao Tong University)

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**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **6** Type: **Oral**

# Rapidity-Spectral Decomposition and Spin Dynamics in Coupled Lorentz Spacetime Coordinates

We present a novel framework for parameterizing Lorentz spacetime coordinates using coupled rapidity parameters, extending classical special relativity with new insights into rapidity symmetries and spin effects. Building upon the Euler–Hamilton formalism, we introduce angular and transverse rapidities, enabling spectral decompositions of relativistic dynamics into elementary functions even when explicit analytic solutions are unavailable. A limiting process is developed to achieve this decomposition, providing new tools for modeling complex relativistic systems. We further expand the relativistic Hamiltonian and Lagrangian into rapidity spectra, yielding a new class of Lorentz coordinates with explicit rapidity dependence. These coordinates are applied to analyze charged particle dynamics in the fields of both plane monochromatic waves and pulsed laser beams. The kinetic energy and trajectory differences arising from the use of classical, rapidity-based, and Fermi-type coordinates are compared in detail. As a key advancement, we incorporate spin degrees of freedom into the rapidity-parametrized formalism. By coupling spin precession equations (via the Bargmann–Michel–Telegdi formalism) with rapidity variables, we derive new spin evolution equations for relativistic particles in 3+1 dimensions. The impact of the new spacetime parametrization on spin-orbit interactions and helicity conservation is analyzed. We also explore the structure of the proper Lorentz group SO(1,3) with coupled parameters, comparing transformations in old, new, and Fermi coordinates. Finally, as a special case, we demonstrate the applicability of our formalism to 1+1 dimensional relativistic hydrodynamics with spin, opening a path toward modeling spin-polarized relativistic fluids. These results contribute to the broader understanding of spin dynamics in high-energy particle and laser–plasma physics.

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**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **8** Type: **Oral**

# He-3/He-4 dilution refrigerator used to cool polarized targets

He–3/He-4 Dilution Refrigerator is the only device at the moment that allows to obtain an ultra-low temperature (down to 5mK) in a continuous mode (for several months and more). In 1966, one of the world's first He–3/He-4 dilution refrigerators was created in Dubna under the leadership of B.S. Neganov. Since then, more than 10 He–3/He-4 dilution refrigerators for experiments with polarized targets have been created in the Low Temperature Department of the DLNP JINR.
At present, He–3/He-4 dilution refrigerators are widely used in various fields of physics and technology: in elementary particle physics - for cooling a target material; in quantum computers - for cooling qubits; in condensed matter physics - to study the properties of matter at ultralow temperatures; in aerospace industry - for cooling detectors of telescopes; etc.
The report will present the operating principle of the He–3/He-4 dilution refrigerator, a description of the design of cryostats created at JINR, as well as a brief description of the experiments where they were installed.

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**Session Classification:** Parallel

**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **9** Type: **Oral**

# Cosmic Ray Muon Polarization to Facilitate Atmospheric Neutrino Physics

Atmospheric neutrinos (ATNs) offer a paradigm to understand neutrino properties while it is critical to quantify uncertainties in the flux modelings. Measurement of cosmic ray muons will contribute to the precision measurement of atmospheric neutrino oscillations due to the same parent particles. This letter suggests measuring the polarization of cosmic ray muons with an array strategy good for understanding low-energy cosmic ray muons and atmospheric neutrinos. Constraints on long-standing atmospheric neutrino flux uncertainties in the few-GeV range are achievable within one year using a $\mathcal{O}(10)\mathrm{m}^2$ array of Cosmic-Ray muon Spin polarization detectoRs (CRmuSRs).

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**Session Classification:** Parallel

**Track Classification:** Low energy spin physics with lepton, photon and hadron probes

Contribution ID: **10** Type: **Oral**

# Development of Polarized 3He at CSNS

The development of polarized neutron technology is pivotal for advancing studies in material science and fundamental physics, particularly in probing magnetic structures and symmetry violations. At the China Spallation Neutron Source (CSNS), significant progress has been made in the design and implementation of polarized 3He neutron spin filters (NSFs) based on spin-exchange optical pumping (SEOP) [1-5]. An off-situ system demonstrated exceptional performance with 77.4% 3He polarization and a polarization lifetime exceeding 200 hours, making it highly suitable for long-duration experiments [2]. The in-situ NSFs also achieve significant progress, building on the first-generation (70 cm × 70 cm × 60 cm, 74.4% $^3$He polarization) [3], a compact in-situ system (55 cm × 56 cm × 48 cm) was developed [4], integrating a uniform magnetic field (<$1.74\times10^{-4}$/cm), dual-laser optical pumping, and precise thermal control (±0.15℃) with low-noise NMR monitoring. Validated on the BL-20 beamline, this system achieved 75.66%±0.09% 3He polarization and 96.30% neutron polarization at 2 Å. These advancements have enabled versatile deployment across multiple CSNS beamlines. For instance, the Back-n white neutron source utilizes the in-situ NSF for time-reversal violation studies [5], while a specially designed in-situ NSF for the Very Small Angle Neutron Scattering (VSANS) instrument successfully implemented China’s first polarization-analyzed small-angle neutron scattering (PASANS) technique [6].

As an underdevelopment polarized neutron facility, our group poised to enhance system stability and expand the applications in complex magnetic materials with polarized neutron, such as investigations of magnetic skyrmions and beyond-Standard Model physics. Future efforts will focus on optimizing performance for advanced experiments in nuclear weak interactions and exotic symmetry-breaking phenomena.

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[3] Zhang, J., Huang, C., Qin, Z. et al. In-situ optical pumping for polarizing 3He neutron spin filters at the China Spallation Neutron Source. Sci. China Phys. Mech. Astron., 65, 241011 (2022).
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[6] Long Tian, Han Gao, Tianhao Wang et al., Polarization-Analyzed Small-Angle Neutron Scattering with an in-situ 3He neutron spin filter at the China Spallation Neutron Source, arXiv:2501.13647 https://doi.org/10.48550/arXiv.2501.13647.

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**Session Classification:** Parallel

**Track Classification:** Application of spin and nuclear polarization techniques

Contribution ID: **12** Type: **Oral**

# Spin polarization at relativistic AA and pA collisions

In this talk, we have implemented the quantum kinetic theory combined the relativistic hydrodynamics to study the spin polarization of Lambda hyperons in the relativistic AA and pA collisions. The global polarization can be well described by the current theoretical frameworks. The local polarization in low energies AA collisions and pA collisions cannot be fully understood.

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**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **13** Type: **Oral**

# Nucleon 3D intrinsic spin structure from the weak-neutral axial-vector form factors

We present the first systematic study of the relativistic intrinsic spin structure of a general spin-$1/2$ hadron in position space. We show in particular that the slope of the nucleon axial form factor $G_A^Z(Q^2)$ in the forward limit, conventionally denoted as $R_A^2 \equiv -\frac{6}{G_A^Z(0)}\frac{\mathrm{d}G_A^Z(Q^2)}{\mathrm{d}Q^2}\Big|_{Q^2=0}$ in the literature, does not faithfully characterize the size of the weak axial charge content of the nucleon in the Breit frame, but corresponds instead to a contribution to the nucleon 3D spin radius $r_{\text{spin}} \equiv \sqrt{\langle r_{\text{spin}}^2\rangle}$, with $\langle r_{\text{spin}}^2\rangle = R_A^2 + \frac{1}{4M^2}\left(1+\frac{G_P^Z(0)}{G_A^Z(0)}\right)$. We derive explicit expressions for the spin radius in different frames, and find in general additional contributions that depend on both the nucleon mass and the forward values of the axial-vector form factors $G_A^Z(0)$ and $G_P^Z(0)$. We also show that the second-class current contribution associated with the induced pseudo-tensor form factor $G_T^Z(Q^2)$ does not contribute in fact to both the nucleon axial and spin radii. Our work paves a new and direct way for investigating the nucleon 3D intrinsic spin structures using the weak-neutral axial-vector form factors $G_{A,P,T}^Z(Q^2)$ extracted from elastic (anti)neutrino-nucleon scattering data, or calculated in lattice QCD and various models and approaches.

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**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **14** Type: **Oral**

# The Gilbert damping factor of heavy quark spin polarization in the magnetic field

In relativistic non-central heavy-ion collisions, both initial angular momentum and a strong magnetic field are generated, leading to the phenomenon of hadron spin polarization. In condensed matter physics, fermions can be spin polarized by the combined effects of spin-magnetic field and spin-orbit interactions. This phenomena has been extensively studied with the Landau-Lifshitz-Gilbert (LLG) equation. When studying the spin polarization of heavy quarks and quarkonium, the phenomenological LLG equation can be an effective approach. The Gilbert damping factor in LLG equation characterizes the spin polarization rate of fermions. In our study, we calculate the transverse susceptibility using linear response theory to express the Gilbert damping constant. We connect the spin polarization rate with the particle scattering cross sections in the medium. The spin polarization rate of heavy quarks are calculated with different potentials and temperatures.

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**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **16** Type: **Oral**

# Spin alignment of vector mesons induced by spin density fluctuation

In recent years, spin polarization of hyperons and the spin alignment of vector mesons were observed by STAR in 20%-60% centrality collision, where the large angular momentum and the magnetic field were supposed to be the main reasons. However, in the most central collision with collision energy 200GeV, the rotation, magnetic field as well as the baryon number should vanish, spin alignment was also observed. Thus, it still remains challenge to explain the experimental data.

In this talk, I will present a new mechanism for the spin alignment of vector mesons: the spin density fluctuation. It is found that the spin alignment of vector meson is sensitive to the spin of constituent strange but is independent of the sign of the spin density, i.e., whether there is more spin-ups than spin-downs or vice versa, the same spin alignment of vector will be obtained. And due to interactions between quarks, especially the tensor and axial-vector interaction, the local spin density will not stay exact zero due to the fluctuation. Thus, though there is no global spin polarization of quarks, local spin density fluctuation will result in none zero spin alignment of vector meson. It is also found that the quark interactions induced by (anti-)instanton could be the source of spin alignment of phi and K^{*0} mesons.

**Primary author:** 许, 坤

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**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **17** Type: **Oral**

# BNL alternating gradient synchrotron with four helical magnets to minimize the losses of the polarized proton beam

The principle of using multiple partial helical magnets to preserve the polarization of the proton beam during its acceleration was applied successfully to the alternating gradient synchrotron (AGS) which currently operates with two partial helical magnets. In this paper we further explore this idea by using four partial helical magnets placed symmetrically in the AGS ring. This provides many advantages over the present setup of the AGS, which uses two partial helical magnets. First, the symmetric placement of the four helical magnets and their relatively lower field of operation allows for better control of the AGS optics with reduced values of the beta functions, especially near beam injection and allows both the vertical and horizontal tunes to be placed within the ‘‘spin tune gap,’’ therefore eliminating the horizontal and vertical intrinsic spin resonances of the AGS during the acceleration cycle. Second, it provides a wider spin tune gap. Third, the vertical spin direction during beam injection and extraction is closer to vertical. Although the spin tune gap, which is created with four partial helices, can also be created with a single or two partial helices, the high field strength of a single helical magnet which is required to generate such a spin tune gap makes the use of the single helical magnet impractical, and that of the two helical magnets rather difficult. In this paper we will provide results on the spin tune and on the optics of the AGS with four partial helical magnets, and compare them with those from the present setup of the AGS that uses two partial helical magnets. Although in this paper we specifically discuss the effect of the four partial helices on the AGS, this method which can eliminate simultaneously the vertical and horizontal intrinsic spin resonances is a general method and can be applied to any medium energy synchrotron which operates in similar energy range like the AGS and provides the required space to accommodate the four helices. In addition, the four partial helix solution is an optimum solution because it eliminates all the spin resonances for any synchrotron which operates in the same energy range as the AGS.

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**Session Classification:** Parallel

**Track Classification:** Acceleration, storage and polarimetry of polarized beams

Contribution ID: **19** Type: **Oral**

# Transverse spin effects and light-quark dipole moments at colliders

We propose a novel series of methods to investigate light-quark dipole interactions at colliders. These methods include: (1) utilizing the azimuthal asymmetry of a collinear dihadron pair $(h_1 h_2)$ produced in association with an additional hadron $h'$ at lepton colliders; (2) examining the azimuthal asymmetries of a collinear dihadron in semi-inclusive deep inelastic lepton scattering off an unpolarized proton target at the Electron-Ion Collider. These asymmetries provide a unique means to observe transversely polarized quarks, which arise from quantum interference in the quark spin space, and are exclusively sensitive to dipole interactions at the leading power of the new physics scale. Consequently, they exhibit a linear dependence on the dipole couplings, free from contamination by other new physics effects. This approach has the potential to significantly strengthen current constraints by one to two orders of magnitude. By combining all possible channels of $h'$, this novel approach enables the disentanglement of the up and down quark dipole moments. Additionally, by controlling the center-of-mass energy and the electron's longitudinal polarization, it separates the contributions of photon and weak boson. Furthermore, it allows for a simultaneous determination of both the real and imaginary parts of the dipole couplings, offering a new avenue for investigating potential $CP$-violating effects at high energies.

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**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **20** Type: **Oral**

# Progress on Constraining the Strange Quark Contribution to the Nucleon Spin

We report on a global fit of neutral-current elastic (NCE) neutrino-scattering data and parity-violating electron-scattering (PVES) data with the goal of determining the strange quark contribution to the vector and axial form factors of the proton. Knowledge of the strangeness contribution to the axial form factor, $G_A^s(Q^2)$, at low $Q^2$ will reveal the strange quark contribution to the nucleon spin, as $G_A^s(Q^2 = 0) = \Delta s$. Previous fits [1,2] of this form included data from a variety of PVES experiments (PVA4, HAPPEx, G0, SAMPLE) and the NCE neutrino and anti-neutrino data from BNL E734. These fits did not constrain $G_A^s(Q^2)$ at low $Q^2$ very well because there was no NCE data for $Q^2 < 0.45$ GeV$^2$. Our new fit includes for the first time MiniBooNE NCE data from both neutrino and anti-neutrino scattering; this experiment used a hydrocarbon target and so a model of the neutrino interaction with the carbon nucleus was required. Three different nuclear models have been employed; a relativistic Fermi gas (RFG) model, the SuperScaling Approximation (SuSA) model, and a spectral function (SF) model [3]. We find a tremendous improvement in the constraint of $G_A^s(Q^2)$ at low $Q^2$ compared to previous work, although more data is needed from NCE measurements that focus on exclusive single-proton final states, for example from MicroBooNE [4]. This work has been published in Physical Review D [5].
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[4] L. Ren, NuFact 2021, PoS, 402, 205 (2022), 10.22323/1.402.0205
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**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **21** Type: **Oral**

# Unveiling Nucleon GPDs through Drell-Yan Processes

The contribution of parton orbital motion to the nucleon spin structure is encoded in transverse-momentum dependent distributions (TMDs) and generalized parton distributions (GPDs). These distributions are primarily accessed through lepton-induced processes such as semi-inclusive deep-inelastic scattering (SIDIS) and Deeply Virtual Compton Scattering (DVCS). As a complementary approach, measurements of (un)polarized Drell-Yan process with hadron beams provide a unique probe, allowing critical tests of the universality properties of TMDs and GPDs between space-like and time-like regimes.
In this talk, we will discuss the interesting results of TMDs results explored by the Drell-Yan process and present the future prospects for accessing nucleon GPDs via the measurements of exclusive pion-induced Drell-Yan process at J-PARC.

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**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **22** Type: **Oral**

# Unifying the study of leading and sub-leading twist PDFs within Dyson-Schwinger equations approach

We study the pion's leading and sub-leading twist PDFs, i.e., f(x) and e(x), using a newly developed technique within Dyson-Schwinger equations approach. We will show how the complexities brought by high Fock-state components, zero mode issue and dynamical chiral symmetry breaking can be handled in a consistent and symmetry-preserving framework that connects continuum QCD dynamics to observable partonic structure.

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**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **23** Type: **Oral**

# qT-slicing with multiple jets at the NNLO and NNLL TMD resummation on dijet production

We present two complementary advances toward precision QCD predictions for multi-jet processes at the LHC, both based on observables constructed with the Winner-Take-All (WTA) recombination scheme. First, we develop two generalizations of the transverse-momentum slicing variable $q_T$ applicable to jet final states, enabling a slicing approach for processes like $pp \to 2$ jets. A proof of concept is provided at NLO, along with factorization formulae that pave the way for NNLO extensions, demonstrated explicitly for $e^+e^- \to 2$ jets. The validation of these $q_T$-like variables crucially relies on the use of WTA axis definition. Second, we perform NNLL resummation for both the $\delta\phi$ and $q_T$ distributions in WTA dijet production, uncovering a novel structure of scale hierarchies in impact-parameter space. We show that large logarithms involving an auxiliary angle $\phi_b$ can be eliminated through refactorization of the soft function and the introduction of additional scale evolution. Together, these developments advance the theoretical toolkit for precision collider phenomenology involving jet observables.

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**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **24** Type: **Oral**

# The b1 Polarized Target Experiment

The University of New Hampshire (UNH) Nuclear Physics Group (NPG) is planning to run the $b_1$ and $A_{zz}$ experiment at JLab in Hall C using an 11.0 GeV, High Luminosity electron beam ($10^{38}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$) with 115 nA beam current, a 5T superconducting magnet, the $ND_3$ dynamically polarized target and the HallC stacked spectrometer to study the deuteron spin observables and asymmetries for polarized beam and target. Additionally, the UNH NPG will implement the tensor enhancement techniques of selective semi-saturated RF(ssRF) and Adiabatic Fast Passage (AFP) that we deployed and tested in Slifer Lab (DeMeritt 103). I will be using my experience with the RGC analysis to prepare for the $b_1$ experiment (Spokesperson Karl Slifer) and for a series of additional tensor polarized target experiments that are planned by the members of the UNH Nuclear Physics Group.

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**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **26** Type: **Oral**

# Measurement of $\Lambda\bar{\Lambda}$ spin correlation in proton-proton collisions at STAR

According to current understanding, the QCD vacuum contains a condensate of quark-antiquark pairs: $u\bar{u}$, $d\bar{d}$, and $s\bar{s}$. Due to the vacuum' s quantum numbers, $J^{PC} = 0^{++}$, these pairs are expected to appear as maximally entangled spin-triplet states with aligned spins. A recent proposal suggests that the $s\bar{s}$ pairs in the quark condensate may be experimentally probed through measurements of spin-spin correlations in $\Lambda\bar{\Lambda}$ hyperon pairs. In this talk, we present the first experimental measurements of spin-spin correlations for $\Lambda\bar{\Lambda}$, $\Lambda\Lambda$, and $\bar{\Lambda}\bar{\Lambda}$ pairs in $p+p$ collisions at $\sqrt{s} = 200\,\text{GeV}$, recorded by the STAR detector in 2012. Both short-range ($|\Delta y| < 0.5$ and $|\Delta\phi| < \pi/3$) and long-range ($0.5 < |\Delta y| < 2.0$, or $\pi/3 < |\Delta\phi| < \pi$) $\Lambda$ hyperon pairs are analyzed. For the first time, a significant spin-spin correlation is observed in short-range $\Lambda\bar{\Lambda}$ pairs, consistent with their origin in the hadronization of maximally spin-entangled $s\bar{s}$ pairs from the QCD vacuum. These results also offer valuable insight into the strange quark hadronization, the spin structure of the $\Lambda$ hyperon, and mechanisms of the spin transfer from polarized protons to $\Lambda$ hyperons.

**Primary author:** VANEK, Jan (Brookhaven National Laboratory)

**Presenter:** VANEK, Jan (Brookhaven National Laboratory)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **27** Type: **Oral**

# Tensor-polarized parton distribution functions for spin-1 hadrons

Structure functions of the spin-1 deuteron will be investigated experimentally from the late 2020's at various facilities such as Thomas Jefferson National Accelerator Facility, Fermi National Accelerator Laboratory, nuclotron-based ion collider facility (NICA), and electron-ion colliders. We expect that a new high-energy spin-physics field could be created by these projects. In this paper [1], the current theoretical status is explained for the structure functions of spin-1 hadrons, especially on parton distribution functions, transverse-momentum dependent parton distributions, and fragmentation functions.

Reference

[1] S. Kumano, Euro. Phys. J. A 60 (2024) 205.

**Primary author:** KUMANO, Shunzo (IMP / KEK)

**Presenter:** KUMANO, Shunzo (IMP / KEK)

**Session Classification:** Parallel

**Track Classification:** Spin physics in nuclear reactions and nuclei

Contribution ID: **28** Type: **Oral**

# Nuclear effects on longitudinal-transverse structure function ratio

It has been assumed that nuclear modification does not exist in the longitudinal-transverse structure function ratio $R_N = F_L^N/(2xF_1^N)$ in lepton deep inelastic scattering. This assumption is widely used in obtaining structure functions of the "nucleon" from nuclear data such as the deuteron ones. However, nuclear modifications do exist theoretically at least at medium- and large-$x$ regions because nucleons in a nucleus move in any direction, which is not necessary the longitudinal direction of the virtual-photon or weak-boson momentum in lepton scattering. Because of this transverse motion, the nucleon's transverse and longitudinal structure functions should mix with each other in nuclei with the mixture probability proportional to the nucleon's transverse momentum squared $\vec{p}_T^{\,2}/Q^2$. In this work [1], numerical results are explicitly shown on such nuclear modifications in the deuteron. These nuclear modifications are important for determining precise structure functions of the nucleon. Furthermore, modifications of $R_N$ should be investigated also at small $x$ by the future electron-ion collider to find interesting gluon dynamics in nuclei. Hopefully, this nuclear effect on $R_N$ could be found by future experimental measurements at lepton accelerator facilities.

Reference
[1] S. Kumano, arXiv:2506.18305.

**Primary author:** KUMANO, Shunzo (IMP / KEK)

**Presenter:** KUMANO, Shunzo (IMP / KEK)

**Session Classification:** Parallel

**Track Classification:** Spin physics in nuclear reactions and nuclei

Contribution ID: **29** Type: **Oral**

# Precision Predictions for Three-Dimensional Nucleon Tomography

We present an analysis of lepton-jet azimuthal decorrelation in deep-inelastic scattering (DIS) at next-to-next-to-next-to-leading logarithmic ($N^3LL$) accuracy, combined with fixed-order corrections at $\mathcal{O}(\alpha_s^2)$. In this study, jets are defined in the lab frame using the anti-$k_T$ clustering algorithm and the winner-take-all recombination scheme. The $N^3LL$ resummation results are derived from the transverse-momentum dependent factorization formula within the soft-collinear effective theory, while the $\mathcal{O}(\alpha_s^2)$ fixed-order matching distribution is calculated using the NLOJET++ event generator. The azimuthal decorrelation between the jet and electron serves as a critical probe of the three-dimensional structure of the nucleon. Our numerical predictions provide a robust framework for precision studies of QCD and the nucleon's internal structure through jet observables in DIS. These results are particularly significant for analyses involving jets in HERA data and the forthcoming electron-ion collider experiments.

**Primary authors:** FANG, Shen (Fudan University); SHAO, Dingyu (Fudan University); LI, Wanchen (Fudan University); TERRY, John

**Co-authors:** 柯 (KE), 伟尧 (Weiyao) (华中师范大学); LI, Haitao (Shandong University); KANG, Zhongbo (UCLA); GAO, Meisen

**Presenter:** FANG, Shen (Fudan University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **30** Type: **Poster**

# 3He/4He Dilution Refrigerator, used to obtain ultra-low temperature (down to 25mK)

3He/4He Dilution Refrigerator is the only device at the moment that allows to obtain an ultra-low temperature (down to 5mK) in a continuous mode (for several months and more). In 1966, one of the world's first 3He/4He dilution refrigerators was created in Dubna under the leadership of B.S. Neganov. Since then, more than 10 3He/4He dilution refrigerators have been created in the Low Temperature Department of the DLNP JINR. At present, 3He/4He dilution refrigerators are widely used in various fields of physics and technology: in elementary particle physics - for cooling a target material; in quantum computers - for cooling qubits; in condensed matter physics - to study the properties of matter at ultralow temperatures; in aerospace industry - for cooling detectors of telescopes; etc.

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Typycal Dubna Dilution Refrigerator main parameters:
- Mixing chamber temperature <30mK
- Cooling power at 300mK > 30mW
- Liquid 4He consumption <3 L/hr
- Sample dimensions: L=20 mm, Ø=20 mm
- Angle for outgoing particles: 0◦<Θ<160◦

**Primary author:** Mr GORODNOV, Ivan (JINR)

**Co-authors:** Dr DOLZHIKOV, Anton (JINR); Mr BORISOV, Nikolay (JINR); Dr USOV, Yuri (JINR)

**Presenter:** Mr GORODNOV, Ivan (JINR)

**Session Classification:** Parallel

**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **31** Type: **Oral**

# The Search for Electric Dipole Moments of Charged Particles in Storage Rings

The dominance of matter over antimatter in the universe remains one of the key unresolved questions in modern physics. According to the Sakharov conditions, this asymmetry requires a violation of CP symmetry. While the Standard Model includes CP-violating effects, they are insufficient to account for the observed imbalance. A promising candidate for additional sources of CP violation is the permanent Electric Dipole Moment (EDM) of particles. The Standard Model predicts extremely small EDMs, while many theories beyond the Standard Model suggest values within experimental reach. To date, all measurements of EDMs have been consistent with zero, providing stringent upper limits on the EDM of various particles.

EDMs must align with a particles' spin, allowing their detection through changes in spin polarization in electric fields. Storage rings are ideal for measuring the EDMs of charged particles, such as the deuteron, for which no experimental limit currently exists. During this talk, I will present the results of the first direct measurement of the deuteron EDM at the Cooler Synchrotron COSY.

**Primary author:** ANDRES, Achim (FZJ / GSI)

**Presenter:** ANDRES, Achim (FZJ / GSI)

**Session Classification:** Parallel

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **32** Type: **Oral**

# Measurement of Transverse Single Spin Asymmetry ($A_N$) of Neutral Pions ($\pi^0$) using Transversely Polarized $p^{\uparrow}p$ collisions at STAR

In proton-proton ($pp$) collisions involving a transversely polarized proton beam and an unpolarized proton beam, a left-right or azimuthal asymmetry is observed in the distribution of final-state scattered particles. The experimentally measurable quantity is known as the Transverse Single Spin Asymmetry ($A_N$). This asymmetry arises from fundamental Transverse Momentum Dependent (TMD) mechanisms involving the interplay between transverse momentum and spin of the participating partons and handrons. While perturbative Quantum Chromodynamics (pQCD) theory predicts very small $A_N$, experimental observations suggest otherwise. Previous measurements of $A_N$ for neutral pions ($\pi^0$) at mid-rapidity ( $|\eta| < 1$) indicate that it is consistent with zero; however, at forward rapidities ($3.3 < \eta < 5.5$), significantly larger values have been observed. Consequently, measurements in the intermediate rapidity range ($1.0 < \eta < 2.0$) are crucial for providing a comprehensive understanding of $A_N$ and the underlying physics processes. The objective of this talk is to present the status of $A_N$ for $\pi^0$ using the STAR Endcap Electromagnetic Calorimeter (EEMC) from STAR Run 2015 transversely polarized $p^{\uparrow}p$ collisions at a center-of-mass energy of 200 GeV. The EEMC's azimuthal coverage across the pseudorapidity range of $1.09 \leq \eta \leq 2.00$ will enable the determination of $A_N$ at intermediate rapidities, and provide a complete picture of the $A_N$ distribution.

**Primary author:** PAUL, Ananya (University of California, Riverside)

**Presenter:** PAUL, Ananya (University of California, Riverside)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **33** Type: **Oral**

# Spin Physics Research INfrastructure and Technologies at NICA (SPRINT@NICA).

The study of the spin effects and polarization phenomena in hadronic reactions is the traditional scientific direction of JINR. Nowadays Spin Physics Detector [1] at NICA as well as new spin projects at the fixed targets [2,3] at Nuclotron are in preparation. This research program requires the development of high intensity polarized beams, polarized targets, beam and focal polarimetry, systems of the spin manipulation and control.
The main goal of the SPRINT@NICA project is to provide the research infrastructure and to develop the technologies for the current and planned spin studies at Nuclotron/NICA. The spin transparency regime for polarized protons and deuterons over whole energy range of Nuclotron and NICA is discussed [4,5]. Further development of the Source of Polarized Ions [6] with corresponding deuteron and proton beam polarimeters is planned. The extension of the spin program to the search of axion-like particles [7] and measurement of the EDM with beams of polarized protons and deuterons [8] is discussed.

[1] V. Abazov et al. (SPD Collaboration) , Natural Science Review 1, 1 (2024).
[2] M. Janek et al., Few Body Syst. 63, 3 (2022),
V.P. Ladygin et al., Phys.Part.Nucl. 53, 251 (2022).
[3] S.N. Basilev et al., Eur.Phys.J.A 56, 26 (2020).
[4] Yu.N.Filatov, Phys.Part.Nucl. 56, 363 (2025).
[5] Yu.N.Filatov et al., JETP Lett. 116 , 413 (2022), JETP Lett. 118, 387 (2023),
JETP Lett. 120, 779 (2024).
[6] A.S. Belov et al., J.Phys.Conf.Ser. 938, 012017 (2017).
[7] S.Karanth et al., (JEDI Collaboration), Phys.Rev.X 13 , 031004 (2023).
[8] Yu.Senichev et al., Phys.Atom.Nucl. 87, 436 (2024).

**Primary author:** LADYGIN, Vladimir (Joint Institute for Nuclear Research, Dubna, Russian Federation)

**Presenter:** LADYGIN, Vladimir (Joint Institute for Nuclear Research, Dubna, Russian Federation)

**Session Classification:** Parallel

**Track Classification:** Acceleration, storage and polarimetry of polarized beams

Contribution ID: **34** Type: **Oral**

# Spin studies with polarized beams at the Nuclotron internal target

Nuclotron Accelerator Complex gives the opportunity to study spin effects using polarized deuteron and proton beams from Source of Polarized Ion. Recent results on the spin effects in deuteron-proton and proton-proton elastic scattering sensitive to the short-range spin structure of the nucleon-nucleon correlations obtained at the internal target at Nuclotron are discussed.
The further perspectives in spin physics program, in the development of the beam polarimetry and proton spin manipulation techniques at Nuclotron are disscussed.

**Primary author:** LADYGIN, Vladimir (Joint Institute for Nuclear Research, Dubna, Russian Federation)

**Presenter:** LADYGIN, Vladimir (Joint Institute for Nuclear Research, Dubna, Russian Federation)

**Session Classification:** Parallel

**Track Classification:** Spin physics in nuclear reactions and nuclei

Contribution ID: **35** Type: **Oral**

# Role of reaction mechanisms in deuteron-proton elastic scattering at GeV energies

The deuteron-proton elastic scattering process is considered in the relativistic
expansion framework. Four reaction mechanisms are taken into account: one-nucleon-exchange, single-scattering, double-scattering terms, and delta-isobar excitation in the intermediate state. Each of these terms contributes into the reaction amplitude.
The model calculates the reaction amplitude, which makes it possible to find the angular dependence
of both the differential cross section and any polarization observables. In this report, I present deuteron and proton analyzing powers, as well as the proton-to-proton polarization transfers in comparison
with the data at the deuteron energy of 1.6 GeV.

**Primary author:** LADYGINA, Nadezhda (JINR LHEP)

**Presenter:** LADYGINA, Nadezhda (JINR LHEP)

**Session Classification:** Parallel

**Track Classification:** Spin physics in nuclear reactions and nuclei

Contribution ID: **36** Type: **Oral**

# Status of experiments with polarized deuteron target at VEPP-3 electron storage ring

The report describes the production of an internal polarized deuteron target for experiments at the VEPP-3 electron storage ring. A description of the measurement of the average target polarization during the experiments is given. The schemes of the system for tagging photons that caused reactions, as well as the system for registering reaction products are presented. The results of the experiments on measuring the component of tensor analyzing power T20 in reactions of negative pi-meson photoproduction γd ⟶ ppπ−, and deuteron photodisintegration γd ⟶ pn are presented.

**Primary author:** TOPORKOV, Dmitriy (Budker Institute of Nuclear Physics)

**Presenter:** TOPORKOV, Dmitriy (Budker Institute of Nuclear Physics)

**Session Classification:** Parallel

**Track Classification:** Spin physics in nuclear reactions and nuclei

Contribution ID: **37** Type: **Oral**

# Measurement of the J/$\psi$ polarization in pp and Pb–Pb collisions with ALICE at the LHC

Quarkonia production in high-energy proton-proton (pp) collisions serves as an important probe for studying quantum chromodynamics (QCD) in vacuum. Understanding the production mechanism of the J/$\psi$, a bound state of a charm and anticharm quark, is essential for constraining both perturbative and non-perturbative aspects of QCD calculations. The polarization of quarkonia in pp collisions is a powerful observable for distinguishing between various QCD-based models of quarkonium production. Furthermore, J/$\psi$ polarization measurements in pp collisions provide a valuable reference for investigating the behavior of charmonium in the quark-gluon plasma formed in nucleus-nucleus collisions.

In this contribution, we will present the first preliminary results of the inclusive J/$\psi$ polarization measurement via the dielectron decay channel at midrapidity (|y| < 0.9) in pp collisions at $\sqrt{s} = 13.6$ TeV. This analysis will be discussed alongside previous J/$\psi$ measurements at forward rapidity and related results, including vector mesons such as $\phi$ and $K^*$ in pp collisions from ALICE Run 2 data. Additionally, the J/$\psi$ polarization with respect to the event plane in heavy-ion collisions will also be discussed.

**Primary author:** BAI, Xiaozhi (University of Science and Technology of China)

**Presenter:** BAI, Xiaozhi (University of Science and Technology of China)

**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **38** Type: **Oral**

# SEARCH FOR TIME-INVARIANCE VIOLATION IN DOUBLE POLARIZED pd-, 3He-d and dd-SCATTERING AND TEST OF THE pN SPIN AMPLITUDES AT HIGH ENERGIES

The total cross section of the interaction of transversaly polarized ($P_y$) proton ($^3$He or deuteron) with the tenzor polarized ($P_{xz}$) deuteron constitues a null-test signal of time-reversal invariance violation under parity conservation (TVPC) in such processes (see Ref. [1] and references therein). This result follows from the optical theorem providing this signal for such kind of double polarized scattering, as a product of unknown constant of the TVPC interaction and the ordinary T-even spin flip helicity $\phi_5$ amplitude of pN-scattering and the deuteron form factor. Knowledge of energy dependence of this signal is necessary for planning experiments and this function was calculated (up to unknown TVPC constant) for pd [1] in the GeV region and recently at energies of SPD NICA for pd [2], $^3$He-d [3] and dd [4] collisions.

Since some of hadronic spin amplitudes of pN elastic scattering are absolutely necessary for search of time-invariance violation in polarization experiments, it is important to have a test of existing parametrizations of these and others spin pN amplitudes especially at high energies where data are non-complete and, therefore, some model parametrizations for pN amplitudes are used [5,6]. As known, spin observables of the pd-elastic scattering in the GeV region are well described on the basis of the spin-dependent Glauber theory [7] using data on spin amplitudes of elastic pp- and pn-scattering. Therefore, spin observables of pd-elastic scattering being analyzed within the Glauber theory can be used as an effective test of existing spin pN-amplitudes. At the NICA SPD collider the asymmetric pd-collision mode will be not implemented, while the symmetric dd-mode will be realized. We show [8] that vector and tenzor analyzing powers $A_y^p$, $A_y^d$, $A_{yy}$, and spin-correlations coefficients $_{y,y}$, $C_{yy,y}$ of the dd⟶ npd reaction for the pole mechanism with a subprocess of quasi-free pd-elastic scattering are directly related to the corresponding spin observables of the free pd-elastic scattering. Most of these observables a very sensitive to the spin pN amplitudes. Therefore measurement of these observables in the reaction dd-npd at SPD NICA in kinematics of quasi free pd-pd process and forthcoming analysis within the Glauber theory will be important as an effective test of available spin pN-amplitudes.

[1] Yu.N. Uzikov, A.A. Temerbayev, Phys. Rev. C 92 (2015) 1, 014002

[2] Yu. N. Uzikov, M.P. Platonova, Phys. Part. Nucl. 56, No. 2, (2025) 533.

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[8] Yu. N. Uzikov, e-Print: 2506.17799 [nucl-th]

**Primary author:** UZIKOV, Yuriy (Joint Institute for Nuclear Researche)

**Presenter:** UZIKOV, Yuriy (Joint Institute for Nuclear Researche)

**Session Classification:** Parallel

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **39** Type: **Oral**

# Unveiling the Collins effect in jets with one-point energy correlators

We propose a novel method to probe the Collins effect, a key signature of the nucleon's 3D structure, using an intra-jet energy correlator. This new observable, based on the energy-weighted azimuthal distribution of hadrons within a jet, can be measured in transversely polarized proton-proton collisions at RHIC. The resulting $\sin(\phi_h - \phi_S)$ single-spin asymmetry provides a direct probe of the Collins fragmentation function, offering a new test of its universality and connecting the fields of spin physics and jet substructure. This creates a strong link between the RHIC spin program and future measurements at the Electron-Ion Collider.

**Primary authors:** GAO, Meisen; KANG, Zhongbo (UCLA); LI, Wanchen (Fudan University); SHAO, Dingyu (Fudan University)

**Presenter:** LI, Wanchen (Fudan University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **40** Type: **Oral**

# Linearly Polarized Photon Fusion as a Precision Probe of the Tau Lepton Dipole Moments at Lepton Colliders

We present a comprehensive investigation into the anomalous magnetic dipole moment ($a_\tau$) and electric dipole moment ($d_\tau$) of the $\tau$ lepton using the $\gamma\gamma \to \tau^+\tau^-$ process at future lepton colliders, with the Super Tau-Charm Facility serving as a benchmark. By employing transverse-momentum-dependent factorization, we introduce novel observables derived from $\cos 2\phi$, $\sin 2\phi$, and $\cos 4\phi$ azimuthal asymmetries to precisely probe the $\tau$ lepton's electromagnetic structure. Our analysis significantly enhances the precision of $a_\tau$ constraints within the photon-photon fusion process, yielding $\mathrm{Re}(a_\tau) \in [-4.5, 6.9] \times 10^{-3}$ at the $2\sigma$ confidence level, which approaches the precision of the Standard Model prediction. These findings highlight the considerable potential of azimuthal asymmetry measurements for high-precision determinations of fundamental particle properties at future lepton colliders.

**Primary author:** XU, Fang (复旦大学)

**Co-authors:** SHAO, Dingyu (CERN, Theoretical Physics Department); YAN, Bin (IHEP); ZHANG, Cheng (杭州师范大学); XIANG, Hao (Fudan University)

**Presenter:** XU, Fang (复旦大学)

**Session Classification:** Parallel

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **41** Type: **Oral**

# Measurement of transverse polarization of $\Lambda/\bar{\Lambda}$ inside jets in unpolarized $pp$ collisions at $\sqrt{s} = 200$ GeV

The fragmentation process has been proposed as a possible origin of the transverse $\Lambda$ polarization, described by polarizing fragmentation functions (pFFs). In $pp$ collisions, this mechanism can be studied by measuring the $\Lambda$ polarization within jets. We present the first measurement of the transverse polarization of $\Lambda/\overline{\Lambda}$ hyperons relative to the jet axis in unpolarized $pp$ collisions at $\sqrt{s} = 200$ GeV, using high-statistics data from the STAR experiment. The dependence of the $\Lambda$ polarization on the jet transverse momentum ($p_T^{\text{jet}}$) is observed. The polarization is also studied as a function of the jet momentum fraction ($z$) carried by the $\Lambda/\overline{\Lambda}$, and the $\Lambda/\overline{\Lambda}$ momentum transverse to the jet axis ($j_T$). These results provide a critical test of the pFFs universality and new insights into the mechanisms behind the transverse $\Lambda$ polarization.

**Primary author:** 高, 涛亚 (Shandong University)

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**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **43** Type: **Oral**

# Accessing the TMD distributions from longitudinal single-spin asymmetries of $W^{\pm}$ bosons at RHIC

Understanding the three-dimensional spin structure of the nucleon is one of the key questions in QCD. Among the transverse-momentum-dependent (TMD) PDFs, the TMD helicity distributions in particular are poorly constrained. Measurements of the longitudinal single-spin asymmetry ($A_L$) of $W^{\pm}$ bosons in polarized proton-proton collisions at RHIC provides a unique opportunity for accessing the flavor separated TMD helicity distributions of quarks and anti-quarks. The $W^{\pm}$ bosons can be identified through their leptonic decay channel ($W \to e+\nu$), and their full kinematics can be constructed by using a recoil-based method. In this talk, we will present the motivation, analysis procedures, and the status of the $A_L$ measurement as functions of $W^{\pm}$ transverse momentum and rapidity, based on the dataset collected by the STAR experiment in longitudinally polarized $p+p$ collisions at $\sqrt{s} = 510$ GeV in 2013.

**Primary author:** WANG, Chao (Shandong University)

**Presenter:** WANG, Chao (Shandong University)

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **44** Type: **Oral**

# Baryon-antibaryon generalized distribution amplitudes

Baryon-antibaryon generalized distribution amplitudes (GDAs) give an access to timelike gravitational form factors (GFFs) which are complementary to the spacelike ones which can be deduced from the hadronic generalized parton distributions (GPDs) measured in deep exclusive electroproduction processes. They allow to probe the GFFs of unstable baryons in the baryon octet, since the second moments of hadronic generalized distribution amplitudes (GDAs) lead to the timelike GFFs.These GDAs can be measured in the process $e^+e^- \to B\bar{B}\gamma$, in the generalized Bjorken regime where the invariant mass of the $B\bar{B}$ pair is near threshold at high energy facilities, such as BESIII, Belle II, and the proposed Super Tau-Charm Facility.In this work, we investigate this process using the QCD collinear factorization framework, where the scattering amplitudes are expressed in terms of the baryon timelike electromagnetic (EM) FFs and Compton FFs. We also provide a numerical estimate of the cross sections with a model for baryon-antibaryon GDAs.Our work provides us a possibility to extract the timelike baryon GFFs from near future experimental measurements,and these GFFs may be further used to study longstanding questions in hadronic physics such as the baryon spin decomposition and D-term.

Reference： Jing Han, B. Pire and Qin-Tao Song, arXiv:2506.09854 [hep-ph].

**Primary authors:** PIRE, Bernard (Ecole polytechnique); HAN, Jing (Zhengzhou University); SONG, Qin-Tao (Zhengzhou University)

**Presenter:** HAN, Jing (Zhengzhou University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **45** Type: **Oral**

# Latest Results from the Muon g-2 Experiment at Fermilab

The muon magnetic anomaly, $a_\mu = (g-2)/2$, can be both measured and computed to a very high precision, making it a powerful probe to test the Standard Model of particle physics and search for new physics. The Fermilab Muon g-2 Collaboration has recently released the third and final measurement of the magnetic anomaly of the positive muon. The measurement shows excellent agreement with the previous measurements and with the previous E821 experiment at Brookhaven (USA). The final record-breaking precision of 127 parts per billion (ppb) surpassed the initial design goal of the experiment. This achievement was possible thanks to both high statistics and to the extensive and scrupolous analysis of the magnetic fields, the beam dynamics, and the particle detection, obtaining a final systematic uncertainty under 80 ppb. This talk will cover the highlights of the latest measurement, discuss its comparison with the latest Standard Model predictions, and provide an outlook on the upcoming analyses.

**Primary author:** GIROTTI, Paolo (INFN - Laboratori Nazionali di Frascati)

**Presenter:** GIROTTI, Paolo (INFN - Laboratori Nazionali di Frascati)

**Session Classification:** Plenary

**Track Classification:** Plenary (invited only)

Contribution ID: **46** Type: **Oral**

# Polarized sold target for possible future AMBER program at CERN

Recently COMPASS showed an interesting result on the d-quark Sivers TMD PDF via SIDIS process with muon beam and the polarized deuteron polarized target. It showed that the d-quark Sivers asymmetry had almost twice larger than u-quark at high-x region.

In order to understand the d-quark OAM contribution on the nucleon spin structure, further measurements via other processes like a Drell-Yan are required. The COMPASS collaboration measured the azimuthal asymmetries which relates to the Sivers TMD PDF via DY process with a negative pion beam and with a proton solid target in 2015 and 2018. We plan to use a positive pion beam and a polarized proton target to obtain a larger asymmetry on the Sivers TMD PDF.

Here I will discuss on the future possible polarized target for this program.

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**Session Classification:** Parallel

**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **47** Type: **Oral**

# Spin asymmetries of eta mesons in polarized proton collisions at PHENIX

For the last two decades, the PHENIX collaboration at Brookhaven National Laboratory has explored nuclear spin physics by leveraging the Relativistic Heavy Ion Collider's unique ability to collide transversely or longitudinally polarized protons. Eta meson production is a particularly practical channel at PHENIX as their detection is possible through diphoton decays in both the central and forward rapidity electromagnetic calorimeters, allowing for a broad reach in both transverse momentum and Feynman-x. In this talk, I will present a recent PHENIX measurement of the transverse single spin asymmetry of eta mesons in the forward rapidity region. This observable is directly sensitive to the twist-3 quark-gluon correlators in both the initial and final state. A comparison between the measurement and a theoretical prediction of the initial-state contribution to the asymmetry suggests that the final state plays a vital role in the generation of the large observed asymmetry. I will also present the status of a measurement of the longitudinal double spin asymmetry from our high luminosity 510 GeV data set. This observable probes the contribution of the gluon polarization to the proton's spin, providing a complementary final state to the earlier PHENIX neutral pion measurement which, for the first time, provided clear evidence of a nonzero gluon polarization.

**Primary author:** LOOMIS, Devon

**Presenter:** LOOMIS, Devon

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **48** Type: **Poster**

# Prospects for the measurement of the D0 transverse single spin asymmetry in transversely polarized proton collisions at sPHENIX

In 2024, the sPHENIX experiment at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory completed its first ever transversely polarized proton data taking, collecting approximately 100 billion unbiased collisions. The sPHENIX tracking system, composed of a vertex detector with monolithic active pixel sensor technology, an intermediate silicon strip detector, and a compact time projection chamber, along with our novel streaming readout data acquisition architecture, is particularly well-suited for precision heavy flavor measurements. One such measurement, uniquely available at sPHENIX, is the D0 meson transverse single spin asymmetry (TSSA). This measurement serves as a remarkably clean probe of the initial-state twist-3 trigluon correlator and is directly related to the gluon Sivers Transverse Momentum Dependent distribution. In this poster, I will present the sPHENIX tracking performance in the 2024 polarized proton run and the prospects for the world’s first measurement of the D0 TSSA.

**Primary author:** LOOMIS, Devon

**Presenter:** LOOMIS, Devon

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **49** Type: **Oral**

# Projected High Precision Measurements on the Spin Structure g1 at EIC

The spin structure function $g_1$ is important for understanding the quark spin contribution to the overall spin of nucleons, which has been a long standing puzzle in nuclear physics. Through the $Q^2$ dependence of $g_1$, the structure function is also sensitive to the gluon spin contribution. In addition, it is important for testing the Bjorken sum rule and can provide a unique way of obtaining the strong coupling constant. $g_1$ can be measured via the longitudinal and transverse double spin asymmetry in polarized deep inelastic scattering, which has been tested at various fixed target experiment in the past. However, to better address the current opened QCD questions as raised earlier, polarized data with wider kinematic coverage reaching low $x$ and high $Q^2$ region are needed. The ePIC detector at the future Electron Ion Collider aims to measure high precision $g_1^p$ and $g_1^n$ from $ep$ DIS and $e^3$He DIS uncovering a large fraction of this previously unexplored area. The details of the experiment and measurement methods will be discussed in this presentation, along with a quantitative projected results estimated using the latest detector simulation and analysis.

**Primary author:** LIN, Win (Stony Brook University)

**Presenter:** LIN, Win (Stony Brook University)

Contribution ID: **50** Type: **Oral**

# Transverse Single Spin Asymmetry of Electromagnetic Jets at Forward Rapidity in p↑+p Collisions at STAR

Transverse single spin asymmetries (TSSAs, denoted AN ) in transversely polarized p↑ + p collisions provide critical insights into the proton' s spin structure, yet their unexpectedly large magnitudes at forward rapidities remain a puzzle. Observed across experiments, including those at RHIC, these asymmetries have yet to be fully explained by theoretical models, such as those based on twist-3 contributions in collinear factorization or transverse momentum dependent (TMD) parton distributions. Recent STAR measurements suggested that diffractive processes may contribute significantly to the observed AN , prompting a deeper investigation into their role.

This talk presents precise measurements of AN for electromagnetic jets in inclusive and diffractive processes from p↑ +p collisions at $\sqrt{s}$ = 200 and 510 GeV, collected using the Forward Meson Spectrometer at STAR ($2.5 < \eta < 4.2$). By isolating diffractive contributions, these results quantify their impact on inclusive AN , providing new constraints on the underlying mechanisms, advancing our understanding of the origins of large TSSAs at forward rapidities.

**Primary author:** ZHANG, Weibin (UC Riverside)

**Presenter:** ZHANG, Weibin (UC Riverside)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **51** Type: **Oral**

# A new experimental proposal to search for T-violating μˆ+ polarization in Kˆ+⟶πˆ0 μˆ+ ν decay using stopped positive kaons at J-PARC

Time reversal symmetry has long been a subject of interest from pre-modern physics time, since it implies the reversibility of motion. In the Kˆ+⟶πˆ0 μˆ+ ν (K_μ3) decay, the transverse muon polarization (P_T) is defined as the polarization component perpendicular to the decay plane. A non-vanishing value of P_T provides clear evidence for T-violation under the condition that spurious effects from final state interactions are negligibly small. We are now proposing a new T-violation experiment to achieve ΔP_T˜10ˆ(-5) at the J-PARC Hadron Hall without using a magnetic spectrometer. The most important characteristic of the new experiment is the measurements of the muon momentum vector, the πˆ0 momentum vector, and the muon polarization by the same highly segmented sequential electro-magnetic calorimeter surrounding the Kˆ+ stopping target. Here it should be noted that one of key issues in the experiment is the choice of a scintillation material which can preserve the muon spin polarization for a reasonably long time [1].
A test experiment to measure residual muon polarization in CeF3, LaF3, PrF3, and NdF3 scintillating crystals was performed using a 100% polarized muon beam at J-PARC MLF. In the longitudinal field of 140 Gauss, the muon polarization in these materials was obtained to be 90% at room temperature, which is high enough to perform the new T-violation experiment [1-3]. Since the calorimeter should be placed very close to the Kˆ+ beam line, a single rate for each module will be very high and the timing resolution should be better than 1 ns to reduce accidental background effects. The timing resolution using a CeF3 crystal with the size of 20×20×20 mmˆ3 was obtained to be ˜100 ps using solar-blind phototubes. The time interval of the two CeF3 detector signals generated by the cosmic ray passage was measured. The timing resolution is sufficiently good, and the accidental backgrounds must be harmless in the proposed T-violation experiment.
The μˆ+ polarization can be determined by the delayed eˆ+ signals from the μˆ+ decay detected by the calorimeter module around the muon stop. The experimental method to measure the eˆ+ asymmetry determination by selecting the πˆ0-forward and backward events is adopted to suppress systematic uncertainties. Furthermore, the analyzing power in the polarization measurement should be improved by measuring the eˆ+ energy using the calorimeter [3] because the magnitude of the eˆ+ asymmetry depends on the eˆ+ energy, while only the energy integrated asymmetry is obtained in the standard polarization measurement. The dedicated analysis method has been developed by separating events into partial energy regions and optimizing weight parameters to averaging the eˆ+ asymmetry in each bin.
In this talk, some details of the future T-violation experiment, the results of the test experiment to determine the residual polarization in CeF3, LaF3, PrF3, and NdF3 materials, the timing resolution of the CeF3 detector, and an increase in the analyzing power in the polarization measurement will be reported.

References

[1] S. Shimizu et al., Nucl. Instrum. Methods A 945 (2019) 162587.
[2] K. Horie et al., Nucl. Instrum. Methods A 1037 (2022) 166932.
[3] Horie et al., Nucl. Instrum. Methods A 1066 (2024) 169606.

**Primary author:** Prof. SHIMIZU, Suguru (The University of Osaka)

**Co-authors:** Dr HORIE, Keito (The University Osaka); Prof. MIHARA, Mototsugu (The University Osaka); Mr IMAI, Ryunosuke (The University Osaka); Mr SHUNGO, Ide (The University of Osaka)

**Presenter:** Prof. SHIMIZU, Suguru (The University of Osaka)

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **52** Type: **Oral**

# The LHCSpin project

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 in the non-perturbative regime of QCD. 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., the inclusive production of c- and b-hadrons, and ideal tool to access the essentially unexplored 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 current status of the LHCspin project is presented, with a focus on the anticipated timeline for its experimental implementation.

**Primary authors:** Prof. CIULLO, Giuseppe (University of Ferrara); Prof. LENISA, Paolo (University of Ferrara); LUCIANO, Pappalardo (University of Ferrara); DI NEZZA, Pasquale (INFN Frascati)

**Presenter:** LUCIANO, Pappalardo (University of Ferrara)

**Track Classification:** Future facilities and experiments

Contribution ID: **53** Type: **Oral**

# Neutral mesons transverse single spin asymmetries in proton-proton collisions with sPHENIX

Neutral mesons transverse single spin asymmetries, $A_N$, provide insights into the spin-orbit correlations inside the nucleon via higher twist correlation functions. As forward rapidities they are known to be very large while at central rapidities vanishing asymmetries have been measured. The sPHENIX experiment with electromagnetic calorimetry over a rapidity range from -1.1 to 1.1 will allow to extend the central rapidity measurements performed by PHENIX and therefore access a region that has not been covered well, yet.
The latest results from the 2024 proton-proton collisions at $\sqrt{s} = 200\,\text{GeV}$ will be presented.

**Primary author:** ROSATI, Marzia (Iowa State University)

**Presenter:** ROSATI, Marzia (Iowa State University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **54** Type: **Oral**

# Central rapidity Jet transverse single spin asymmetry measurements in proton-proton collisions with sPHENIX

Jet transverse single spin asymmetries, $A_N$, are only sensitive to the initial state effects as final state effects are not present. They are therefore an excellent tool to single out the quark-gluon and tri-gluon correlation functions that are the higher-twist equivalents to the transverse momentum moments of the Sivers functions for quarks and gluons. sPHENIX has taken transversely polarized proton-proton collision data at $\sqrt{s} = 200\,GeV$ using a large acceptance full electromagnetic and hadronic calorimetry to reconstruct jets. The status of the jet $A_N$ measurements will be presented.

**Primary author:** ROSATI, Marzia (Iowa State University)

**Presenter:** ROSATI, Marzia (Iowa State University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **55** Type: **Oral**

# Isolated photon single spin transverse single spin asymmetries with sPHENIX

Direct photon single spin asymmetries, $A_N$, have the advantage that they are not sensitive to final state effects and that the hard scattering process is predominantly quark-gluon scattering at RHIC energies. Therefore, direct photons provide a clean probe to study the quark-gluon and tri-gluon correlations in single spin asymmetries with particularly the latter hardly constrained at present. The larger and more hermetic acceptance of sPHENIX compared to PHENIX is expected to improve the precision of the previous direct photon AN measurements using the 2024 polarized proton-proton collisions that were recorded in sPHENIX. The status of the direct photon $A_N$ measurements will be presented.

**Primary author:** ROSATI, Marzia (Iowa State University)

**Presenter:** ROSATI, Marzia (Iowa State University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **56** Type: **Oral**

# Measurement of $\Lambda/\bar{\Lambda}$ Transverse Polarization within Jets in $pp$ Collisions at $\sqrt{s} = 510$ GeV

The transverse polarization of $\Lambda$ hyperons in unpolarized hadron–hadron reactions, first observed decades ago, is still not fully understood. The polarizing fragmentation functions, which are expected to contribute to the $\Lambda$ polarization, can be investigated by measuring the $\Lambda/\bar{\Lambda}$ transverse polarization inside jets in $pp$ collisions. In this contribution, we will present the status of our analysis on $\Lambda/\bar{\Lambda}$ polarization within jets based on $pp$ collisions at $\sqrt{s} = 510$ GeV collected by the STAR detector at RHIC in 2017.Comparisons of the measurements at different energies in $pp$ collisions and $e^+e^-$ annihilation processes can probe the energy scale dependence and test the universality of the polarizing fragmentation functions.

**Primary author:** HE, Jinhao (Shandong University)

**Presenter:** HE, Jinhao (Shandong University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **57** Type: **Oral**

# Spin manipulation in atomic and molecular systems for nuclear spin applications

Nuclear spin polarization has important applications across various fields, including physics and medicine. It also offers several advantages, such as cross-section enhancement, in the five-nucleon fusion reactions, namely the D-T and D-$^3$He reactions. This work presents a theoretical study of spin dynamics in the hyperfine regime for selected atomic and molecular systems and explores alternative techniques to generate or enhance nuclear spin polarization in these systems. Particular emphasis is placed on coherent spin manipulation strategies and the role of hyperfine interactions in transferring angular momentum from electronic (in atoms) or rotational (in molecules) to nuclear degrees of freedom.

**Primary author:** KANNIS, Chrysovalantis (Heinrich-Heine-Universität Düsseldorf)

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**Presenter:** KANNIS, Chrysovalantis (Heinrich-Heine-Universität Düsseldorf)

**Track Classification:** Application of spin and nuclear polarization techniques

Contribution ID: **58** Type: **Oral**

# Compton Form Factor Extraction using Quantum Deep Neural Networks

We present a comparative study of Compton Form Factor (CFF) extraction using pseudodata derived from Deeply Virtual Compton Scattering (DVCS) experiments at Jefferson Lab. The analysis is based on the twist-two formalism of Belitsky, Kirchner, and Müller, incorporating a minimally biased fitting strategy inspired by local fits to reduce model dependence. Two machine learning approaches are explored: Classical Deep Neural Networks (CDNNs) and Quantum Deep Neural Networks (QDNNs). Our results show that QDNNs generally outperform their classical counterparts in both accuracy and precision, particularly in scenarios constrained by limited model complexity with large experimental errors and data sparsity. These findings highlight the promising role of quantum-enhanced learning techniques in the extraction of hadronic structure observables and suggest a viable path forward for future quantum-optimized analyses in spin-dependent exclusive processes.

**Primary author:** LE, Brandon (University of Virginia)

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**Presenter:** LE, Brandon (University of Virginia)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **59** Type: **Oral**

# A Proposal to Measure Nucleon Axial-Vector Form Factor using Polarized Electron Beam

The form factors are important physical quantities that characterize the internal structure of a nucleon. In the classical picture, it corresponds to the Fourier transform of the nucleon's three-dimensional density distribution. Among them, the electromagnetic form factors are the most well-known, with thousands of high-precision experimental data accumulated to date. The axial form factor is another essential type of nucleon form factor. It is not only a crucial input for neutrino oscillation experiments but also plays a significant role in constraining the nucleon's generalized parton distribution functions. However, compared to the electromagnetic form factors, the axial form factor suffers from both a scarcity of data and limited precision. Traditionally, its measurement relies on neutrino scattering and near-threshold pion electroproduction, both of which face inherent limitations. In this talk, I will present a novel measurement scheme and experimental concept based on high-precision polarized electron beams, which promises to overcome many of the shortcomings of existing methods. This experiment is planned to be carried out at Jefferson Lab and is currently in the design phase.

**Primary author:** XIONG, Weizhi (Shandong University)

**Presenter:** XIONG, Weizhi (Shandong University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **60** Type: **Oral**

# Current developments of polarized sources and polarimeter at FZ Jülich and further applications

A better theoretical understanding of the quantum mechanical processes in spin filter for the separation of metastable hydrogen atoms in individual hyperfine substates enables a number of new applications. For example, it is now possible to build a new generation of Lamb-shift polarimeter that can separate not only α but also the β states with $m_J = -1/2$. This opens up completely new possibilities for the search of hydrogen atoms in forbidden substates after the bound beta decay of the neutron. At the same time, corresponding simulations also provide the parameters for designing a Lamb-shift polarimeter for $^3He^+$ ions. Furthermore, it has recently been shown that classical Lamb-shift polarimeter can determine the polarization, in addition to protons/deuterons and $H/D$ atoms, of $H_2/D_2$ molecules as well as all possible ion beam species, i.e. $H_2^+/D_2^+/HD^+$, $H^-/D^-$ or even $H_3^+$.

In parallel, this knowledge might help to create a new type of optically pumped polarized source by transferring a laser-induced polarization of the rotational magnetic moment to the nucleons in $H_2/D_2$ and HD molecules. These techniques might also be used for the production and detection of polarized fuel for the enhancement of the energy output of nuclear fusion reactors or the production of hyperpolarized probes in medicine.

A recent application was a proof-of-principle measurement of the polarization conservation in $H_2$ molecules after recombination of polarized atoms in a carbon-coated storage cell, similar to the cell that is foreseen for a planned polarized target at the LHCb experiment. In addition, in some more exotic experiments the components of a Lamb-shift polarimeter can be used to detect axions or "dark hydrogen".

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**Presenter:** Dr ENGELS, Ralf (Forschungszentrum Jülich)

**Track Classification:** Application of spin and nuclear polarization techniques

Contribution ID: **61** Type: **Oral**

# High-Precision Determination of Quark Spin in Lattice QCD: A Novel Method

We propose a "blending" algorithm that projects the all-to-all fermion propagator onto spatial low-frequency modes (LFM) combined with a stochastic estimate of spatial high-frequency modes (SHFM) at each time slice.
This approach enables the calculation of arbitrary-point correlation functions for arbitrary hadron states in strongly interacting quantum field theories (QFT) with fermions, such as quantum chromodynamics (QCD).
Specifically, LFM allows the construction of spatially extended hadron states below a certain energy threshold by diagonalizing multi-fermion interpolation fields. Meanwhile, the local interactions required for N-point correlation functions in QFT can be approximated in an unbiased manner through a reweighted summation of both LFM and SHFM contributions.
To demonstrate the efficiency of this algorithm, we obtained {\color{black} $g_A^u = 0.895(15)$, $g_A^d = -0.338(15)$, $g_A^s = -0.0245(72)$, $g_A^{u+d+s} = 0.533(28)$ and $g_A^{u-d} = 1.2339(43)$ } for nucleon at $m_\pi = 300$ MeV and $a = 0.077$ fm using 40 configurations.
The consistency check of the pion electric form factor and charge radius derived from 3-point and 4-point correlation functions is also provided.

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**Presenter:** 胡, 志成 (Chinese Academy of Sciences Institute of Modern Physics)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **62** Type: **Oral**

# Measurements of Λ, Ξ and Ω Global Polarization in Au+Au collisions at BES-II energies from RHIC-STAR

The observation of hyperon global polarization along the system's angular momentum has revealed the existence of large vorticities in the medium created by heavy-ion collisions. In this talk, we present measurements of global polarization for Λ, Ξ, and Ω hyperons in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 9.2, 11.5, 14.6, 17.3, 19.6, and 27 GeV, based on high-statistics data collected during the RHIC Beam Energy Scan Phase II (BES-II) with the upgraded STAR detector. The comparison between Λ and $\bar{\Lambda}$ polarizations offers potential access to magnetic-field-driven effects. The inclusion of multi-strange hyperons such as Ξ and Ω introduces additional sensitivity to the later-stage dynamics of the system, placing further constraints on the properties of the QGP and the evolution of its angular momentum. These results provide new insights into the polarization mechanism and the structure of the vorticity fields in heavy-ion collisions.

**Primary author:** 付, 🄵 (山东大学)

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**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **63** Type: **Oral**

# Semi-inclusive deep inelastic scattering off a tensor-polarized spin-1 target

We investigate semi-inclusive deep inelastic scattering (SIDIS) off a tensor-polarized spin-1 target, focusing on the production of an unpolarized hadron. We derive a comprehensive differential cross-section expression, characterized by 23 structure functions, which depend on the target spin states and the azimuthal distribution of the final-state hadron.
Within the TMD factorization framework, we perform a tree-level calculation of the hadronic tensor using quark-quark correlator and quark-gluon-quark correlator up to twist-3.
This yields 21 nonvanishing structure functions at leading and subleading twist, expressed in terms of TMD PDFs and TMD FFs. The measurement of these nonzero structure functions can be utilized to explore the tensor-polarized structure for spin-1 particles, offering insights into their internal dynamics.

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**Presenter:** Dr ZHAO, Jing (Shandong University )

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **64** Type: **Oral**

# Toward the first experiments of T-violation search in neutron-induced compound nuclear reaction

The CP violation beyond the standard model is not only physically interesting on its own, but also a key for understanding the baryon asymmetry in the current universe. In a low energy region, instead of directly probing it, many efforts to search the violation of time-reversal symmetry(T-violation) continue in various physics systems with high sensitivity. Among those, neutron-induced compound nuclear reactions are interesting because the enhancement of parity-nonconservation effect(PNC) has been found in many compound nuclear states. Particularly, in the neutron resonant absorption in Lanthernum nuclei(La) at 0.75eV, the enhancement is so great that it reaches 10ˆ6. This enhancement for the PNC can be also expected for the T-violation from recent experimental results and theoretical calculations. Additionally, this system is sensitive to a different physical parameter indicating the magnitude of the T-violation from the neutron EDM, so that it is also attractive in terms of a different search region. Thus, the NOPTREX collaboration is planning the T-violation search with La targets as a first attempt. One big issue is the development of a polarized La target because polarized targets except for proton and deuteron have not been realized yet as a practical use. In this presentation, we will introduce the overview of the first stage of the T-violation experiment, Phase-I, and report current status in the NOPTREX project.

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**Presenter:** IINUMA, Masataka (Hiroshima University, AdSE)

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **65** Type: **Poster**

# Measurement of residual μˆ+ polarization in a CeF3 material and timing resolution of a CeF3 detector to search for T-violating μˆ+ polarization in Kˆ+⟶πˆ0 μˆ+ ν decay

Time reversal symmetry has long been a subject of interest from pre-modern physics time, since it implies the reversibility of motion. In the Kˆ+⟶πˆ0 μˆ+ ν (K_μ3) decay, the transverse muon polarization (P_T) is defined as the polarization component perpendicular to the decay plane. A non-vanishing value of P_T provide clear evidence for T-violation under the condition that spurious effects from final state interactions are negligibly small. We are now proposing a new T-violation experiment to achieve ΔP_T˜10ˆ(-5) at the J-PARC Hadron Hall without using a magnetic spectrometer. The most important characteristics of the new experiment is the measurements of the muon momentum vector, the πˆ0 momentum vector, and the muon polarization by the same highly segmented sequential electro-magnetic calorimeter surrounding the Kˆ+ stopping target. Here it should be noted that one of key issues in the experiment is the choice of a scintillation material which can preserve the muon spin polarization for a reasonably long time [1].
A test experiment to measure residual muon polarization in CeF3, LaF3, PrF3, and NdF3 scintillating crystals was performed using a 100% polarized muon beam at J-PARC MLF. In the longitudinal field of 140 Gauss, the muon polarization in these materials was obtained to be 90% at room temperature, which is high enough to perform the new T-violation experiment [1-3]. Since the calorimeter should be placed very close to the Kˆ+ beam line, a single rate for each module will be very high and the timing resolution must be better than 1 ns to reduce accidental background effects. The timing resolution using a CeF3 crystal with the size of 20×20×20 mmˆ3 was obtained to be ˜100 ps using solar-blind phototubes. The time interval of the two CeF3 detector signals generated by the cosmic ray passage was measured. The timing resolution is sufficiently good, and the accidental background must be harmless in the proposed T-violation experiment.
In this talk, some details of the future T-violation experiment, the results of the test experiment to determine the residual polarization in CeF3, LaF3, PrF3, and NdF3 materials and the measurement of the CeF3 timing resolution will be reported.

References

[1] S. Shimizu et al., Nucl. Instrum. Methods A 945 (2019) 162587.
[2] K. Horie et al., Nucl. Instrum. Methods A 1037 (2022) 166932.
[3] Horie et al., Nucl. Instrum. Methods A 1066 (2024) 169606.

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Contribution ID: **66** Type: **Oral**

# Spin physics at HIAF

The High Intensity heavy-ion Accelerator Facility (HIAF) will be a major workhorse for the accelerator-based (sub)atomic physics in the multi-GeV region in the next decades. As fundamental as the mass, spin plays a profound role in the structure of microscopic particles and interactions among them. Besides, spin has long provided unique approaches to test fundamental symmetries and to search for new physics beyond the Standard Model of particle physics.

In order to extend the discovery potential of HIAF in the fields of spin-dependent dynamics/structure and symmetry tests, developments of tools for spin-polarized experiments, such as polarized ion sources, acceleration of polarized beams and beam polarimetry, are currently ongoing. A variety of experiments with processes $p\vec{p}$, $p\vec{e}$, $A\vec{e}$, $A\vec{d}$ at different scales, ranging from atomic physics, over nuclear physics, down to hadron physics, can be performed at HIAF. This talk will discuss a few highlighted physical programs and related R&D activities.

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**Presenter:** GOU, Boxing (Institute of Modern Physics, CAS)

Contribution ID: **67** Type: **Oral**

# Gravitational form factors in the perturbative limit

The generalized distribution amplitudes (GDAs) have attracted attention in recent years because of their relation with the energy momentum tensor (EMT) form factors (FFs). The GDAs can be experimentally accessed through the study of amplitudes in $\gamma^*\gamma \to M_1M_2$ and $\gamma^* \to M_1M_2\gamma$, where $M_1M_2$ is a pseudoscalar meson pair such as $\pi\eta$ and $\eta\eta'$. In this paper we calculate these amplitudes in the perturbative limit where the $M_1M_2$ GDAs are expressed in terms of meson distribution amplitudes which have been constrained in the previous experiments. Our explicit calculation verifies the existence of a new EMT FF that breaks the conservation law of EMT when the hadronic matrix element of the EMT operator is examined for a single quark flavor. In addition, our result shows that the $M_1M_2$ GDAs are identical in $\gamma^*\gamma \to M_1M_2$ and $\gamma^* \to M_1M_2\gamma$, which confirms the universality of GDAs in the perturbative limit. In future, the GDAs and EMT FFs studied in this paper can be investigated at Belle II. Our study enhances the accessibility to the $P$-wave GDAs in $\gamma^*\gamma \to M_1M_2$ and $\gamma^* \to M_1M_2\gamma$ and gives a promising way to search for exotic hybrid mesons in the future experiment.

**Primary authors:** SONG, Qin-Tao (Zhengzhou University); Prof. TERYAEV, Oleg (Joint Institute for Nuclear Research, Russia); Dr YOSHIDA, Shinsuke (South China Normal University)

**Presenter:** SONG, Qin-Tao (Zhengzhou University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **68** Type: **Oral**

# Development of a Polarized H/D Gas Target at IMP

In high-energy nuclear physics, spin plays a crucial role in the composition of matter and the interaction between particles. The Institute of Modern Physics, Chinese Academy of Sciences, plans to develop polarized beams and targets for spin-related studies at the High Intensity heavy-ion Accelerator Facility (HIAF). The target is mainly composed of an atomic beam source, a target chamber and a Breit-Rabi polarimeter. Currently, design work for a high-performance polarized H/D gas target, including mechanical design and track/spin simulation, is ongoing.
In order to achieve high beam intensity and high degree of polarization, the spin-filtering sextupole magnets and the spin-flipping transition units, are emulated in terms of atomic spin\trajectory tracking and numerical calculations of hyperfine transition via solving the time-dependent Schrödinger equation. In this talk, I will present the current status of our target design, with an emphasis on key component optimization.

**Primary authors:** LV, Xiaorong (Institute of Modern Physics, CAS); GOU, Boxing (Institute of Modern Physics, CAS)

**Presenter:** LV, Xiaorong (Institute of Modern Physics, CAS)

**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **69** Type: **Oral**

# Polarized neutron application at the China Spallation neutron source

Neutron beams generated at the China Spallation Neutron Source (CSNS) are dedicated for material characterization through scattering process. Polarization can be introduced before and after the neutron scatter with the sample so that neutron magnetic dipole interaction with local magnetization can be observed, know as polarized neutron scattering. The polarized neutron can be expanded to nuclear physics through observing the polarized neutron and polarized nuclei reaction. Some interesting interference and resonance method for can also be achieved through carefully arranged neutron polarization precession.
In this talk, we introduce the recently development of the polarized neutron experiment capability at the CSNS, focusing on effort of setting up polarized neutron for exotic measurement. Specifically, we give detailed demonstration on setting up polarization and analysis for eV level neutron for the purpose of symmetry violation measurement. Development of in-house made neutron adiabatic radio-frequency and its application on Ramsey resonance method shall also be introduced.

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**Co-authors:** 张俊佩, Junpei (高能所); Mr QIN, Xu (SunYat-Sen University School of Physics and Astronomy); Dr TIAN, Long (Institute of High Energy Physics)

**Presenter:** WANG, Tianhao (中科院高能物理研究所)

**Track Classification:** Application of spin and nuclear polarization techniques

Contribution ID: **70** Type: **Oral**

# The acceleration and spin direction control of tensor-polarized deuteron beams in a synchrotron

To investigate the internal spin structure of nucleons and explore fundamental phenomena such as parity and time-reversal symmetry violations, polarized deuteron beams play a pivotal role as they serve as a unique substitute for polarized neutron beams and enable access to tensor polarization—a critical feature of spin-1 systems that provides distinct insights beyond vector polarization. This study advances the understanding of tensor-polarized deuteron beam dynamics in synchrotrons, with direct relevance to the Electron-Ion Collider in China (EicC). By deriving spin tensor transfer matrices and validating their accuracy through numerical simulations, we demonstrate tensor polarization evolution in bending magnets, solenoids, and quadrupoles. The analysis of depolarizing resonances during acceleration reveals negligible polarization losses under the EicC's operational parameters, ensuring the feasibility of high-precision spin experiments without dedicated polarization maintenance. Furthermore, the planar-constrained translational dynamics of spin tensors, fundamentally distinct from the rotational mechanisms governing spin vectors, offer novel strategies for spin manipulation in future accelerators. These results provide theoretical and computational foundations for spin tensor control in the EicC and broader applications in spin-correlation experiments.

**Primary author:** 李, 民祥 (Institute of modern physics, Chinese Academy of Sciences)

**Presenter:** 李, 民祥 (Institute of modern physics, Chinese Academy of Sciences)

Contribution ID: **71** Type: **Oral**

# Probing Meson Structure via Lattice QCD: EMFF at high $Q^2$ and GPD

We present lattice QCD computations addressing crucial aspects of meson internal structure through electromagnetic form factors (EMFFs) and generalized parton distributions (GPDs). Utilizing physical masses and fine lattices, we calculate pion and kaon EMFFs at momentum transfers up to approximately 10 and 28 GeV$^2$, respectively, achieving good agreement with available experimental data at low momentum transfers and providing essential ab-initio benchmarks for upcoming high-energy experiments. Additionally, we compute the x-dependent valence pion GPDs at zero skewness across various momentum transfers by employing advanced renormalization and matching schemes, and also deliver a three-dimensional image of the pion structure in impact-parameter space.

The talk is based on
[1] H.T.Ding, X.Gao, A.D.Hanlon et al., Phys.Rev.Lett. 133 (2024) 18, 181902
[2] H.T.Ding, X.Gao, S.Mukherjee et et al., JHEP 02(2025)056

**Primary author:** DING, Heng-Tong (Central China Normal University)

**Presenter:** DING, Heng-Tong (Central China Normal University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **72** Type: **Oral**

# Development of a Polarized Hˆ+/Dˆ+ Ion Source at IMP

Spin is a fundamental property of particles and plays a crucial role in particle structure and interactions. In a polarized ion beam, the spins of ions favor a particular direction, which is not only crucial for spin physics research but also beneficial for cutting-edge physics experiments that require high precision. For producing intense polarized ion beams, a Spin Polarized Ion Source (SPIS) is under development at the Institute of Modern Physics (IMP, CAS). It is intended to produce polarized proton (deuteron) ion beams of 1 mA, 25 keV, with 100 $\mu$s pulse width, 5 Hz repetition frequency and polarization of no less than 80%. In this paper, a SPIS consisting of a Polarized Atomic Beam Source (PABS) and a plasma ionizer will be presented. An advanced Lamb-shift Polarimeter (LSP) with a measurement precision of 1% that could be completed within a few seconds have been successfully tested. This polarized ion source will eventually be installed to the HIAF (High Intensity heavy ion Accelerator Facility) injector that will enable HIAF to deliver 9.3 GeV polarized proton and 4.6 GeV polarized deuteron beams. It will not only support a wide range of frontier physical experiments but also pave the way towards the Electron-Ion Collider in China (EicC) strategy.

**Primary authors:** Mr ZHAI, yaojie (Institute of Modern Physics, Chinese Academy of Sciences); Mr ZHANG, sheng (Institute of Modern Physics, Chinese Academy of Sciences); Dr JIN, Qianyu (Institute of Modern Physics, Chinese Academy of Sciences); Dr GOU, Boxing (Institute of Modern Physics, CAS); Mr LI, Minxiang (Institute of Modern Physics, Chinese Academy of Sciences); Mr WANG, Penghui (Institute of Modern Physics, Chinese Academy of Sciences); Ms ZHANG, Xuezhen (Institute of Modern Physics, Chinese Academy of Sciences); Dr LIANGTING, Sun (Institute of Modern Physics, Chinese Academy of Sciences)

**Presenter:** Mr ZHAI, yaojie (Institute of Modern Physics, Chinese Academy of Sciences)

**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **74** Type: **Oral**

# Polarized beam studies for CEPC and BEPCII

This presentation will overview the study of polarized lepton beams in the context of resonant depolarization and longitudinal polarized colliding beams, for the 100km scale Circular Electron Positron Collider (CEPC), including design studies and R&D progress, as well as the potential of attaining longitudinal polarization at BEPCII.

**Primary author:** Prof. DUAN, Zhe (高能所)

**Presenter:** Prof. DUAN, Zhe (高能所)

Contribution ID: **75** Type: **Oral**

# Hidden-Color Effects in Deuteron Structure

We explore the internal structure of the deuteron within the light-front framework, going beyond the traditional proton–neutron description. By incorporating hidden-color degrees of freedom, we model the deuteron as an effective mixture of singlet–singlet and octet–octet color configurations. Our study includes both unpolarized and polarized observables, including the tensor-polarized structure function $b_1$, as well as electromagnetic form factors. The results highlight the important role of hidden-color components in shaping the deuteron ' s spin and partonic structure, providing insights for future spin physics experiments.

**Primary author:** KAUR, Satvir

**Presenter:** KAUR, Satvir

**Session Classification:** Parallel

**Track Classification:** Spin physics in nuclear reactions and nuclei

Contribution ID: **76** Type: **Oral**

# Energy Independence of the Collins Asymmetry in pp Collisions

The study of the Collins asymmetry in $p^{\uparrow}p$ collisions provides a crucial experimental probe for quark transversities and polarized transverse-momentum-dependent (TMD) fragmentation functions.
In this talk, we present high-precision measurements of the Collins asymmetry for $\pi^{\pm}$ within jets from transversely polarized $p^{\uparrow}p$ collisions at $\sqrt{s}$ = 510 GeV by using the STAR detector.
In terms of an energy-scaled jet transverse momentum ratio, $x_{\mathrm{T}} = 2p_{\mathrm{T,jet}}/\sqrt{s}$, a remarkable consistency is observed for Collins asymmetry of $\pi^{\pm}$ between $\sqrt{s}$ = 200 GeV and 510 GeV. This indicates that the Collins asymmetry is nearly energy independent, with at most a mild scale dependence, in $p^{\uparrow}p$ collisions.
The experimental results are compared to theoretical calculations, including models with and without TMD evolution.
Thus, these results enable unique tests of evolution and universality in the TMD formalism, providing important constraints for the transversity distributions and the Collins fragmentation functions.

**Primary author:** 张, 宜新 (山东大学)

**Presenter:** 张, 宜新 (山东大学)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **77** Type: **Oral**

# Quenching of polarized jets

Jets produced in association with a $Z^0$ or $W^{\pm}$ boson in hadronic collisions are naturally polarized due to the parity violation of weak interaction, making these processes ideal for extracting information about the longitudinal spin transfer $G_{1L}$, and for studying the phenomenon of polarized jet quenching. In this work, we compute the polarization of $\Lambda$ hyperons in $pp$ collisions and investigate the nuclear modification due to the jet-medium interaction in $AA$ collisions. We demonstrate that this quantity is a sensitive probe to the energy loss effect.

**Primary authors:** Mr YAO, Wenhao (Shandong University); Ms LI, Xiaowen (Shandong University); Mr DONG, Hui (Shandong University); Mr WEI, Shuyi (Shandong University)

**Presenter:** Mr YAO, Wenhao (Shandong University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **78** Type: **Oral**

# Polarized TMD FFs with QCD evolution

The polarized transverse-mementum-dependent fragmentation function (TMD FF) $D_{1T}^{\perp}$ have attracted lots of attention from both experiment and theory communities. Starting from a isospin symmetric parametrization for $D_{1T}^{\perp}$, we have studied transverse polarizations of $\Lambda$ in various collisions. Recently we focus on nuclear collisions and study the QGP medium effects via QCD evolution in the impact parameter space. We find that transverse polarization of $\Lambda$ can work as a novel probe of nuclear medium effects in heavy ion collisions.

**Primary author:** SONG, Yu-kun (University of Jinan)

**Presenter:** SONG, Yu-kun (University of Jinan)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **79** Type: **Oral**

# Development and Testing of a 5 MeV Mott Polarimeter for Precision Measurement of Polarization for P2

The P2 experiment at Mainz Energy-Recovering Superconducting Accelerator (MESA) aims to measure the Weinberg angle with an uncertainty of 0.15%. This implies that the uncertainty of the beam polarization measurement must be less than 1%. To achieve this, a polarimetry chain with polarimeters operating at different energies and principles is being developed.

As a part of this polarimetry chain, a 5 MeV Mott polarimeter has been fabricated, installed, and tested at the MAMI facility. The results of these tests will be presented during this talk.

**Primary author:** THAPA, Rakshya (Johannes Gutenberg University of Mainz)

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**Presenter:** THAPA, Rakshya (Johannes Gutenberg University of Mainz)

Contribution ID: **80** Type: **Oral**

# Suppression of Spin Transfer to $\Lambda$ in Deep Inelastic Scattering

We investigate $\Lambda$ production in semi-inclusive deep inelastic scattering using a polarized lepton beam and find that the spin transfer is significantly suppressed by target fragmentation. As further demonstrated by a model estimation, experimental data can be well described once the target fragmentation is taken into account. Our findings suggest that, at the medium-energy scales of existing fixed-target experiments, such as JLab, COMPASS and HERMES, the separation of current and target fragmentation regions is not distinct. The spin suppression effect from target fragmentation not only alleviates the tension between data and theoretical predictions with current fragmentation, but also provides a new perspective to explore the hadronization mechanism. This effect can be further tested at high energy levels in the future experiments.

**Primary author:** 赵, 晓燕 (山东大学前沿交叉科学青岛研究院)

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**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **81** Type: **Oral**

# ART25 (a recent global TMD fit)

After the conceptual improvements to transverse momentum dependent (TMD) extractions of a flavour dependent ansatz as well as a more robust propagation of uncertainties onto the resulting TMD functions in ART23, the following work ART25 is a state of the art determination of the unpolarised TMD parton distribution functions and -fragmentation functions such as the Collins-Soper kernel via a global fit on the available data.

With a simplistic model we achieve a good result for the fit and describe the data in the relevant phase space, provided by measurements of the semi-inclusive DIS and the Drell-Yan process.

In my talk I am going to review the framework of the extraction,
present the results of this work
and comment on aspects on which this type of fits can improve on.

**Primary authors:** Dr VLADIMIROV, Alexey (Universidad Complutense de Madrid); MOOS, Valentin (NYCU); Prof. SCIMEMI, Ignazio (Universidad Complutense de Madrid); Dr ZURITA, Pia (Universidad Complutense de Madrid)

**Presenter:** MOOS, Valentin (NYCU)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **82** Type: **Oral**

# Hyperon local polarization in pPb collisions at CMS

The observation of hyperon polarization along beam direction ($P_z$) in nucleus-nucleus collisions has opened a new way to study the complex vortical structures of the QGP. With the high-statistics data collected by the CMS experiment, we present the first $P_z$ results for $\Lambda$ and $\bar{\Lambda}$ particles in pPb collision at $\sqrt{s_{NN}} = 8.16$ TeV over a wide transverse momentum ($p_T$) and charged particle multiplicity ($N_{\mathrm{trk}}^{\mathrm{offline}}$) range. The $P_z$ values decrease as a function of $N_{\mathrm{trk}}^{\mathrm{offline}}$, but increase with $p_T$. A hydrodynamic model that describes the observed $P_z$ values in nucleus-nucleus collisions by introducing vorticity effects does not reproduce either the sign or the magnitude of the pPb results. These observations pose a challenge to the current theoretical implementation of spin polarization in heavy ion collisions and offer new insights into the origin of spin polarization in hadronic collisions at LHC energies.

**Primary authors:** LI, Chenyan; ZHANG, Jinlong (Shandong University); CHEN, Zhenyu (Shandong University)

**Presenter:** LI, Chenyan

**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **83** Type: **Oral**

# Transverse momentum dependent helicity distributions

In this talk, I will present the first extraction of TMD helicity distributions, by analyzing double spin asymmetry data from SIDIS.

**Primary author:** Dr YANG, Ke (山东大学)

**Presenter:** Dr YANG, Ke (山东大学)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **84** Type: **Oral**

# Upgrading Polarized Beam Equipment at the JINR Accelerator Facility: Future Prospects

At the JINR accelerator complex, within the polarization research program of the NICA project, the high-intensity SPI source of polarized deuterons and protons and low-energy polarimeters are being developed for the SPI setup at the outlet and behind the 5 MeV/nucleon linear accelerator. The status, upgrades of the above facilities, future prospects are presented.

[1] G.V. Trubnikov, N.N. Agapov, O.I. Brovko, A.V. Butenko, E.D. Donets, A.V. Eliseev, V.V. Fimushkin et al., Proc. of the 4th Int. Particle Accelerator Conf. IPAC2013, TUPFI009 1343 (2013).
[2] A.S. Belov, D.E. Donets, V.V. Fimushkin, A.D. Kovalenko, L.V. Kutuzova, Yu.V. Prokofichev, V.B. Shutov, A.V. Turbabin, and V.N. Zubets, J. Phys. Conf. Ser. 938, 012017 (2017).
[3] V.V. Fimushkin, A.D. Kovalenko, R.A. Kuzyakin, M.V. Kulikov, L.V. Kutuzova, Yu.A. Plis, Yu.V. Prokofichev, V.B. Shutov, A.S. Belov, A.V. Turbabin, and V.N. Zubets, PoS 324, 019 (2018).
[4] V.V. Fimushkin, R.A. Kuzyakin, M.V. Kulikov, L.V. Kutuzova, Yu.V. Prokofichev, A.M. Shumkov, A.S. Belov, A.V. Turbabin, and V.N. Zubets, PoS 346, 114 (2019).

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**Presenter:** FIMUSHKIN, Viktor (Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia)

**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **85** Type: **Oral**

# Spin-Polarized Proton-Boron (p-$^{11}$B) Fusion: Pathways to Clean Energy

Proton-boron (p-$^{11}$B) fusion is widely recognized as a promising candidate for future clean energy due to its advantages of abundant fuel, inherent safety, and minimal neutron emissions. However, the practical realization of p-$^{11}$B fusion faces significant challenges, primarily due to its stringent ignition conditions and relatively low reaction cross-section. Recently, spin polarization has emerged as a potential method to enhance the reaction rate and improve the feasibility of p-$^{11}$B fusion. This presentation reviews the current status and recent progress in p-$^{11}$B fusion research, emphasizing the role of spin-polarized fuel in improving reaction efficiency, and discussing the innovative approaches proposed by ENN Energy Research Institute using spherical torus (ST). Additionally, we highlight theoretical and experimental studies on spin-polarized p-$^{11}$B fusion, including cross-section measurements, fuel (especially boron) preparation, plasma generation and sustainment. The synergy between advanced magnetic confinement configurations, such as ST, and spin-polarized fuel is identified as a promising pathway toward commercial fusion energy. Finally, we outline future research directions and collaborative opportunities within the spin-polarization physics community to accelerate the development of p-$^{11}$B fusion as a viable energy source.

**Primary author:** Dr LI, ZHI

**Presenter:** Dr LI, ZHI

**Track Classification:** Application of spin and nuclear polarization techniques

Contribution ID: **86** Type: **Oral**

# Proposal for the Charge-Exchange Ionizer Test Bench with Transverse Injection of Polarized Atomic Beams (H/D)

The JINR accelerator complex utilizes the SPI source [1] for generating polarized deuteron and proton beams, based on atomic beam technology with accumulation in a charge-exchange plasma ionizer. The traditional collinear scheme has limitations, including increased beam divergence and higher emittance, which reduce generation efficiency.

To address these issues, an design with a T-shaped storage cell and transverse injection of the atomic beam has been proposed. This configuration reduces system dimensions, increases polarized atom density, and improves beam quality through lower emittance.

The development builds on methodologies described in [1,2] and demonstrates potential for achieving the target luminosity.

[1] Belov A.S. et al., J. Phys.: Conf. Ser. 938 (2017)
[2] Belov A.S., AIP Conf. Proc. 980 (2008)

**Primary authors:** Dr BELOV, Aleksandr (Institute for Nuclear Research of RAS); SOLOVEV, Aleksandr (Joint Institute for Nuclear Research (JINR)); IVSHIN, Kuzma (JINR); Mrs KUTUZOVA, Ludmila (Joint Institute for Nuclear Research (JINR)); Mr KULIKOV, Michail (Joint Institute for Nuclear Research (JINR)); FIMUSHKIN, Viktor (JINR)

**Presenter:** SOLOVEV, Aleksandr (Joint Institute for Nuclear Research (JINR))

**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **87** Type: **Oral**

# New concept of general-purpose spectrometer with proton polarimeter function

we propose a novel approach to measure the final-state proton polarization in large-acceptance collider experiments. Using existing tracking devices and supporting structure material, general-purpose spectrometers can be utilized as a large-acceptance polarimeter without hardware upgrade. This approach is tested at BESIII, and can be applied at nearly all major facilities, such as Belle-II, CMS, ATLAS, LHCb, CBM, EIC etc., enabling general-purpose spectrometer to extract final-state proton polarization in addition to the traditional four-momentum measurements. This capability would vastly expand the physics reach of these experiments, and has potential for substantial impact across nuclear and particle physics.

**Primary author:** LIANG, Yutie (Institute of Modern Physics, CAS)

**Co-authors:** Prof. KUPSC, Andrzej; Dr BOXING, Gou; Prof. HAIBO, Li; XIAORONG, Lv

**Presenter:** LIANG, Yutie (Institute of Modern Physics, CAS)

**Track Classification:** Application of spin and nuclear polarization techniques

Contribution ID: **88** Type: **Oral**

# Low energy polarimeters at the JINR acceleration complex

To produce high-intensity polarized beams of deuterons and protons, the Laboratory of High Energy Physics (LHEP) at JINR is developing a Source of Polarized Ion (SPI).
Within the framework of the SPI project, low-energy polarimeters are being developed to measure degree of polarization during beam transport at energies up to 5 MeV/n. These include:
• An NRP (Nuclear Reaction Polarimeter) is for optimizing the operation of nuclear polarization RF-units and vertical spin orientation at the SPI output, including the linear accelerator section
• A $^{3}$He - 4He polarimeter for measuring polarization parameters at the outlet of the 5 MeV/n linear accelerator

**Primary authors:** SOLOVEV, Aleksandr (Joint Institute for Nuclear Research (JINR)); IVSHIN, Kuzma (Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia); Dr ZELENSKY, Anatoly (Moscow Institute of Physics and Technology (MIPT), Institutskii per., 9, Dolgoprudny, Moscow Region, 141700, Russia.); FIMUSHKIN, Viktor (Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia); Dr DUNIN, Vladimir (Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia)

**Presenter:** IVSHIN, Kuzma (Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia)

Contribution ID: **89** Type: **Oral**

# Measurement of Anti-Quark Sivers Asymmetry at FNAL-SpinQuest

SpinQuest at Fermilab is a fixed-target experiment to primarily measure the Drell-Yan process using transversely polarized $NH_3$ and $ND_3$ targets and unpolarized 120-GeV proton beam. In the Drell-Yan process, a quark in one scattering hadron and an anti-quark in the other hadron annihilate into a virtual photon and then decay into a muon (lepton) pair. The angular distribution of final-state muon pairs with respect to the target polarization is sensitive to the Sivers function of light anti-quarks in the nucleon, which is one of the eight leading-twist Transverse Momentum Dependent (TMD) parton distribution functions. The Sivers function of each anti-up and anti-down quarks can be extracted by the use of the $NH_3$ and $ND_3$ targets for $p$+$p$ and $p$+$d$ reactions. The intensity of the proton beam is as high as $2 \times 10^{12}$ protons/second, in order to accumulate the required number of Drell-Yan events. The $J/\psi$ and $\psi'$ productions are measured together, which is also sensitive to the Sivers functions of light anti-quarks and gluons. SpinQuest commissioned the target and the spectrometer with the proton beam in May-July 2024. The status of analyses of the commissioning data and preparation for the next data taking will be presented.

**Primary author:** NAKANO, Kenichi (University of Virginia)

**Presenter:** NAKANO, Kenichi (University of Virginia)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **90** Type: **Oral**

# Hyperon-Nucleon Spectrometer at HIAF

Hyperons were found to be polarized in p-Be collisions at Fermilab as early as 1976, 12 years before the EMC results sparked the "proton spin crisis." Since then, polarized Lambda hyperons have been observed in electron-positron, proton-proton, and proton-ion collisions. However, unlike the extensive study of nucleon spin structure, the origin of Lambda polarization lacks systematic investigation, both theoretically and experimentally. Starting in 2026, the High Intensity heavy-ion Accelerator Facility (HIAF) in Huizhou, China, will deliver high-intensity proton beams (up to ˜10 GeV) and various ion beams. This talk presents a proposal for a Hyperon-Nucleon Spectrometer at HIAF, designed to perform multi-dimensional mapping of Lambda polarization in fixed-target p-p, p-A, and A-A collisions.

**Primary author:** ZHAO, Yuxiang (Institute of Modern Physics, Chinese Academy of Sciences)

**Presenter:** ZHAO, Yuxiang (Institute of Modern Physics, Chinese Academy of Sciences)

**Session Classification:** Parallel

**Track Classification:** Future facilities and experiments

Contribution ID: **91** Type: **Oral**

# extremely strong evidence of CPV in baryon-anti-baryon production processes of heavy hadron decays

The violation of the charge-parity (CP) transformation symmetry, which although has been observed in plenty of pure meson decay processes, was only confirmed just very recently by the LHCb collaboration in the four-body decay of the heavy baryon $\Lambda_b^0$, $\Lambda_b^0 \to pK^-\pi^+\pi^-$, through a comparison of the decay branching ratio with that of the CP-conjugate process. However, the detailed dynamics behind this CP asymmetry is obviously far from clear. In this talk, we propose a formalism for the full analysis of the decay angular correlations in four-body cascade decays of heavy hadrons which can provide more information about the CP violation in these decays.
To illustrate this, we apply the decay angular correlation analysis of CP violation to another four-body decay channel that involve baryons, $B^0 \to p\bar{p}K^+\pi^-$, which has also been investigated by the LHCb collaboration with no evidence of CP violation being found. Surprisingly, with the event yield extracted inversely from the published data of LHCb, we obtain non-zero CP asymmetries of about $10\%$ corresponding to the decay angular correlations at larger than $5\sigma$ confidence level, which are considerably larger than the CPA asymmetries observed in the $\Lambda_b^0 \to pK^-\pi^+\pi^-$ channel, indicating that CP violation could have been observed in processes involving baryons much earlier if the full analysis of angular correlations had been performed. We suggest our experimental colleagues to perform full decay angular correlation analyses of CP violation in four-body decays of heavy hadrons, including the above two decay channels.

**Primary authors:** Mr YANG (杨), Jian-Yu (健宇) (University of South China); Prof. GUO (郭), Xin-Heng (新恒) (Beijing Normal University); Prof. ZHANG（张）, Zhen-Hua（振华）(University of South China)

**Presenter:** Prof. ZHANG（张）, Zhen-Hua（振华）(University of South China)

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **92** Type: **Oral**

# Detector development for EicC at HIAF

The proposed Electron-Ion Collider in China (EicC) envisions advancing China's future High-Intensity heavy-ion Accelerator Facility (HIAF) through strategic upgrades to establish a polarized electron-ion collider. This premier facility will provide a comprehensive experimental platform for nuclear physics, particle physics, and related scientific disciplines in China. Functioning as a modern analogue to Rutherford scattering experiments, the electron-ion collider represents an unparalleled instrument for probing the deep structure of matter. This report details EicC's primary physics goals alongside current progress in detector system design and R&D initiatives.

**Primary author:** GUO, Aiqiang (Institute of modern physics, Chinese Academy of Sciences)

**Presenter:** GUO, Aiqiang (Institute of modern physics, Chinese Academy of Sciences)

**Session Classification:** Parallel

**Track Classification:** Future facilities and experiments

Contribution ID: **93** Type: **Oral**

# Development of a Polarized H/D atom Source for the EicC Project

The Electron-Ion Collider in China (EicC) is a proposed high-intensity facility designed to explore the partonic structure of nucleons and nuclei, particularly in the sea quark region, with unprecedented precision. Its physics program aims to uncover the origin of nucleon mass and spin, image the three-dimensional landscape of partons, study quark-gluon dynamics in nuclei, and search for exotic hadronic states. These ambitious objectives demand high-luminosity collisions involving polarized beams with both high intensity and polarization, making advanced polarized source development a crucial step.

A polarized hydrogen and deuterium (H/D) ion source is currently under development at the Institute of Modern Physics, following the Atomic Beam Polarized Ion Source (ABPIS) scheme. The target performance is a beam polarization above 0.8 and an ion beam intensity exceeding 1 mA. The system incorporates two sets of sextupole magnets and three radiofrequency transition (RFT) units, which have been carefully designed and optimized for high polarization efficiency.

So far, an H atomic beam flux exceeding $3\times10^{16}$ atoms/s has been measured by a hot cathode ion gauge. When the weak field transition (WFT) unit placed between two sets of sextupole magnets is turned on, the atomic beam flux decreases by about 50% compared to when the WFT is turned off, indicating the occurrence of effective spin state transitions. Further RFT tests and beamline optimization are ongoing.

**Primary authors:** ZHANG, SHENG (The Institute of Modern Physics (IMP) of the Chinese Academy of Sciences); Mr ZHAI, yaojie (Institute of Modern Physics, CAS); JIN, Qianyu (Institute of Modern Physics, CAS); LIU, shijun (Institute of Modern Physics, CAS); WANG, Penghui (Institute of Modern Physics, Chinese Academy of Sciences); ZHANG, Xuezheng (Institute of Modern Physics, CAS); SUN, Liangting (Institute of Modern Physics, CAS)

**Presenter:** ZHANG, SHENG (The Institute of Modern Physics (IMP) of the Chinese Academy of Sciences)

**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **94** Type: **Oral**

# The SoLID-TMD Program at Jefferson Lab

The Solenoidal Large Intensity Device (SoLID) is an advanced spectrometer under development in Hall A at Jefferson Lab. Designed for high-luminosity operation ($10^{37}$–$10^{39}$ $cm^{-2}s^{-1}$) with both polarized (NH3 and 3He) and unpolarized hydrogen and deuterium targets, SoLID features large acceptance and full azimuthal coverage. It will fully exploit the capabilities of the 12 GeV CEBAF upgrade and is optimized for a broad range of physics programs, including precision measurements in semi-inclusive deep inelastic scattering (SIDIS) for three-dimensional nucleon imaging in momentum space. Several highly rated SIDIS experiments have been approved to extract transverse momentum dependent parton distribution functions (TMDs) with unprecedented precision. The current 11 GeV electron beam will allow SoLID to explore TMDs in the important valence quark region, and the proposed future 22 GeV upgrade will extend its kinematic range significantly. In this presentation, we will introduce the SIDIS program at Jefferson Lab using SoLID, highlight associated parallel run-group opportunities, and present updated impact on extracting TMDs.

**Primary author:** YE, Zhihong (Tsinghua University)

**Presenter:** YE, Zhihong (Tsinghua University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **95** Type: **Oral**

# Nucleon gluon PDF from lattice QCD

The unpolarized and polarized gluon parton distribution functions are calculated in lattice QCD using the Large-Momentum Effective Theory(LaMET) method. The calculations are carried out at three different lattice spacings and pion mass around 300MeV. The results are extrapolated to the continuum and infinite momentum limits. The unpolarized gluon PDF is consistent with the global fit of CT18NNLO.

**Primary authors:** Ms CHEN, Chen (Institute of Modern Physics, CAS); Mr DONG, Hongxin; LIU, Liuming (Institute of Modern Physics, CAS); Prof. SUN, Peng (Institute of Modern Physics, CAS); YANG, Yi-Bo (ITP/CAS); Dr YAO, Fei; ZHANG, Jianhui (The Chinese University of Hong Kong, Shenzhen); Ms ZHONG, Shiyi

**Presenter:** LIU, Liuming (Institute of Modern Physics, CAS)

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **96** Type: **Poster**

# Design and implementation of a laser Compton polarimeter at BEPCII-U

As a key R&D item of polarized lepton beams for future colliders, a laser Compton polarimeter has been designed for the electron storage ring of BEPCII, reusing the X-ray beamline and experimental hutch of a dismantled wiggler source. This article will describe the design considerations of the Compton polarimeter, report the first phase beamline modification and preliminary beam commissioning results, and discuss potential performance improvements in the near future.

**Primary author:** SU, Mengyu

**Co-authors:** DUAN, Zhe (高能所); MARTENS, Aurélien (Université Paris Saclay, Laboratoire de Physique des 2 Infinis Irène Joliot Curie (IJCLab)); LIANG ZHIJUN, 梁志均; 张月雷, UNKNOWN; TANG, Guangyi (IHEP); JI, Daheng (高能所); ZHU DECHONG, UNKNOWN (高能所); MA, zh; 于程辉, Chenghui (Institute of High Energy Physics); 周, 宁闯 (高能所); 张, 婉; 王建力, Jianli (高能所); 李延春, UNKNOWN (高能所); 韩庆夫, han (高能所)

**Presenter:** SU, Mengyu

Contribution ID: **97** Type: **Oral**

# Polarimetry of pulsed $H^-/D^-$ ion beams: Extended applicability of the Lamb-shift polarimeter

Until 2023, a polarized $H^-/D^-$ ion source delivered pulsed negative ion beams for stripping injection into the COSY accelerator. Accurate and efficient measurement of the nuclear spin polarization directly behind the source is essential for precision experiments at COSY. A data acquisition system was developed to enable reliable, automated measurements with improved efficiency and to reduce operator intervention. To achieve that, the applicability of the Lamb-shift polarimeter has been successfully expanded to include pulsed $H^-$ and $D^-$ ion beams. The presented setup is useful and suitable to determine and optimize the polarization of upcoming polarized sources of the COSY type without pre-acceleration. We also present additional measurements of the nuclear spin polarization of $H_3^+$ ion beams with a Lamb-shift polarimeter.

**Primary author:** PÜTZ, Simon Jakob (University of Cologne/GSI)

**Co-authors:** ENGELS, Ralf (Forschungszentrum Jülich); FAATZ, Nicolas; KANNIS, Chrysovalantis (Heinrich-Heine-Universität Düsseldorf); Dr GEBEL, Ralf (GSI Darmstadt); Dr GRIGORYEV, Kirill (GSI Darmstadt); Dr VALDAU, Yury (GSI Darmstadt); EL-KORDY, Tarek (FH Aachen-University of Applied Sciences and Institute of Technology and Engineering, Forschungszentrum Jülich)

**Presenter:** PÜTZ, Simon Jakob (University of Cologne/GSI)

Contribution ID: **98** Type: **Oral**

# Hydrodynamic effects on spin polarization in AA and pA collisions

We have implemented the 3+1 dimensional CLVisc hydrodynamics model with \trento-3D initial conditions to investigate the spin polarization of $\Lambda$ hyperons along the beam direction in p+Pb collisions at $\sqrt{s_{NN}} = 8.16$ TeV. Following our previous theoretical framework based on quantum kinetic theory, we consider three different scenarios: $\Lambda$ equilibrium, $s$ quark equilibrium, and iso-thermal equilibrium scenarios. We have computed the second Fourier sine coefficients of spin polarization along the beam direction, denoted as $\langle P_z \sin 2(\phi_p - \Psi_2)\rangle$, with $\phi_p - \Psi_2$ being the azimuthal angle relative to the second-order event plane $\Psi_2$, as functions of multiplicity, transverse momentum and pseudo-rapidity in the three scenarios. Additionally, we have also computed the spin polarization along the beam direction, $P_z$, as a function of the azimuthal angle. We find that the spin polarization induced by thermal vorticity always provides an opposite contribution compared to the shear-induced polarization in p+Pb collisions. The total spin polarization computed by the current hydrodynamic model disagrees with the data measured by LHC-CMS experiments.

**Primary authors:** YI, Cong (USTC); WU, Xiang-Yu (Central China Normal University); PU, Shi (University of Science and Technology of China); QIN, Guang-You (Central China Normal University)

**Presenter:** YI, Cong (USTC)

**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **99** Type: **Oral**

# Transverse Momentum Dependent Parton Distributions and EicC Projection

We present the global analysis of Sivers functions, worm-gear distribution functions, transversity distribution functions, and Collins fragmentation functions within the transverse momentum dependent factorization. This analysis encompasses the latest data from SIDIS, DY, and W±/Z-boson production processes. In addition, based on a combined analysis of world data and simulated data, we quantitatively demonstrate the impact of the proposed Electron-Ion Collider in China on precise determinations of the Sivers, worm-gear and transversity distributions.

**Primary authors:** ZENG, Chunhua (IMP); DONG, Hongxin (NNU); YANG, Ke (山东大学); SUN, Peng (IMP, CAS); LIU, Tianbo (Shandong University); ZHAO, Yuxiang (University of Science and Technology of China (USTC))

**Presenter:** DONG, Hongxin (NNU)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **100** Type: **Oral**

# \bf{PREFER} (\bf{P}olarization for \bf{F}usion \bf{E}xperiments and \bf{R}eactors: what is moving around the fusion with polarized fuel?

The **PREFER** (**P**olarization **RE**search for **F**usion **E**xperiments and **R**eactors) collaboration aims to address the know-hows in different fields and techniques to the challenging bet on energy production by nuclear fusion with polarized fuel. The collaboration involves different institutions and researchers, sharing skills and peculiar abilities, having then possibilities to span over a variety of tasks and objectives, which are under the responsibility of the authors of this contribution, leading their groups.
The collaborators, each in their own activities, starting from facing open questions in the fusion reaction physics, already reach promising results, which have also acted as an inspiration and stimulus for other groups and investigations.
In the following we will report in the present status of the collaboration results and working plans, opening a window on what is being moved around.

**Primary author:** Prof. CIULLO, Giuseppe (INFN-Ferrara and Dipartimento di Fisica e SdT dell'Università di Ferrara)

**Co-authors:** Dr ENGELS, Ralf (Forschungszentrum Jülich); Prof. BÜSCHER, Markus (PGI - Forschungszentrum Jülich and PGI-FZJ - 52425 Jülich and H.H.-University of Düsseldorf); Prof. RAKITZIS, T. Peter ( IESL-FORTH and Crete University - Greece)

**Presenter:** Prof. CIULLO, Giuseppe (INFN-Ferrara and Dipartimento di Fisica e SdT dell'Università di Ferrara)

**Track Classification:** Application of spin and nuclear polarization techniques

Contribution ID: **101** Type: **Oral**

# Design, Control, and Monitoring of the SpinQuest Polarized Target System

The SpinQuest experiment leverages a transversely polarized solid-state target to investigate the orbital angular momentum of the nucleon by probing sea quarks through the Drell-Yan process, enabling a measurement of the Sivers asymmetry. The Drell–Yan process is initiated by Fermilab ' s 120 GeV Main Injector proton beam, delivering intensities of up to 3E12 protons per 4-second spill. The target system employs Dynamic Nuclear Polarization (DNP) to polarize irradiated ammonia ($NH_3/ND_3$) at a magnetic field of 5T and a base temperature of 1 K, maintained by a 5 W helium evaporation refrigerator. The polarized material is housed in an 8 cm-long oval-shaped target cell. Efficient cooling is facilitated by a high-capacity roots pump stack, providing a pumping rate of 17,000 $m^3$/h. Polarization is driven by a 140 GHz Extended Interaction Oscillator (EIO) that induces the necessary spin transitions for DNP. To ensure stable and reliable operation, an intelligent monitoring and control system is proposed that leverages Artificial Intelligence for real-time condition monitoring, fault detection, and diagnosis. This talk presents an overview of the SpinQuest polarized target system, along with the design and future implementation of the associated diagnostic and control framework.

**Primary authors:** Dr KELLER, Dustin (University of Virginia); ROBERTS, Jordan (SpinQuest)

**Presenter:** ROBERTS, Jordan (SpinQuest)

**Track Classification:** Application of spin and nuclear polarization techniques

Contribution ID: **102** Type: **Oral**

# Fragmentation function studies at BESIII

Abstract: Fragmentation Function (FF) plays a crucial role in describing the hadronization process. We report the measurements of normalized differential cross sections of inclusive pi0 and Ks production as a function of hadron momentum at six energy points with qˆ2 transfer from 5 to 13 GeVˆ2 at BESIII. The results with a relative hadron energy coverage from 0.1 to 0.9 significantly deviate from several
theoretical calculations based on existing fragmentation functions.

**Primary author:** ZHANG, Yateng (ZZU)

**Presenter:** ZHANG, Yateng (ZZU)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **103** Type: **Oral**

# Determining spin effects in global equilibrium by quantum kinetic theory

In this talk, we will demonstrate how quantum kinetic theory determines spin effects in global equilibrium. We show that by generalizing from constant to varying electromagnetic fields, previously indeterminate spin effects induced by vorticity and electromagnetic fields can now be further pinned down.

**Primary author:** GAO, Jian-Hua (Shandong University at Weihai)

**Presenter:** GAO, Jian-Hua (Shandong University at Weihai)

**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **104** Type: **Oral**

# Measurements of hyperon spin correlation in Au+Au collisions at BES-II energies at STAR

The observation of hyperon global polarization and vector meson spin alignment in heavy-ion collisions has revealed that spin phenomena are important probes of quark matter properties. These findings point toward possible spin correlations between quarks and antiquarks in the quark-gluon plasma. Such correlations are sensitive to production mechanism and evolution dynamics of spin polarization, as well as the interplay between spin and the other dynamical degrees of freedom in the collision system. In this talk, we report the status of spin correlation measurements of Lambda-(anti)-Lambda hyperon pairs in Au+Au collisions at BES-II energies (7.7-27 GeV) at RHIC-STAR. The results provide insights into the spin polarization mechanism in heavy-ion collisions, and shed light on fundemental properties of strong interactions and color confinement.

**Primary author:** GOU, Xingrui

**Presenter:** GOU, Xingrui

**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **105** Type: **Oral**

# Application of Deep Learning in Polarized Target Nuclear Magnetic Resonance Measurements

Continuous wave Nuclear Magnetic Resonance (NMR) with constant current has been pivotal in solid-state polarized target experiments within Nuclear and High Energy Particle physics. Phase-sensitive detection using a Liverpool Q-meter is conventionally employed for monitoring polarization during scattering experiments. Yet, when operating outside of designed operational parameters, there are significant nonlinearities have not yet been well understood for high-fidelity running. Additionally under experimental conditions low signal to noise can lead to much larger experimental uncertainties reducing the overall figure of merit of the scattering experiments. This presentation discusses recent advancements aimed at enhancing data acquisitions in NMR-based polarization measurements and extending the operational capabilities of the Q-meter beyond its designated parameters using machine learning (ML) to analyze measurements with a low signal-to-noise ratio (SNR), corresponding to high noise levels. This innovative approach enables more effective real-time online polarization monitoring and offline data analysis, thereby enhancing the overall performance metrics in scattering experiments involving Spin-1 target material.

**Primary author:** SEAY, Devin (University of Virginia)

**Co-authors:** Dr FERNANDO, Ishara (University of Virginia); KELLER, Dustin (University of Virginia)

**Presenter:** SEAY, Devin (University of Virginia)

Contribution ID: **106** Type: **Oral**

# Measurement of the transverse single spin asymmetry for forward neutral pions in (non-)diffractive like events at RHICf and STAR

The transverse single-spin asymmetry ($A_{\mathrm{N}}$) serves as a crucial probe for understanding the mechanisms of particle production in polarized high energy particle collisions as well as the internal dynamics of quarks and gluons within a polarized nucleon. The RHICf collaboration measured a non-zero transverse single-spin asymmetry ($A_{\mathrm{N}}$) for very forward ($\eta > 6$) neutral pions ($\pi^0$) in transversely polarized $p + p$ collisions at $\sqrt{s} = 510$ GeV within the STAR experiment. This measurement, along with a similar analysis performed at STAR for forward $\pi^0$s, $2.7 < \eta < 4.0$, suggests that diffractive interactions could be primarily responsible for the observed $A_{\mathrm{N}}$. To quantitatively determine the extent to which diffractive and non-diffractive processes contribute to the RHICf $A_{\mathrm{N}}$, we conduct a joint analysis of the very forward $\pi^0$ $A_{\mathrm{N}}$ using both RHICf and STAR detector systems from the same collisions. We report preliminary results of $\pi^0$ $A_{\mathrm{N}}$ in diffractive-like and non-diffractive-like event categories, and discuss the current status of this ongoing analysis.

**Primary author:** LEE, Seunghwan (RIKEN, Sejong University)

**Presenter:** LEE, Seunghwan (RIKEN, Sejong University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **107** Type: **Oral**

# The progress of Super Tau Charm Facility in China

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 0.5×10ˆ35 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.

**Primary authors:** Prof. PENG, Haiping; YAN, Wenbiao (University of Science and Technology of China)

**Presenter:** Prof. PENG, Haiping

**Session Classification:** Parallel

**Track Classification:** Future facilities and experiments

Contribution ID: **109** Type: **Oral**

# Accurate B meson and Bottomonium masses and decay constants from the tadpole improved clover ensembles

Using the anisotropic relativistic fermion action on isotropic lattice, we present a systematic study of the masses and lepton decay constants of the mesons with the bottom quark based on the 2+1 flavor tadpole improved clover ensembles at six different lattice spacings from 0.05 to 0.11 fm, various pion masses from 130 to 360 MeV, and several values of the strange quark mass. We also propose a systematic framework to renormalize the quark bi-linear operators with the bottom quark field, and verify it through the renormalized bottom quark mass and decay constants.

**Primary authors:** Mr DU, Haiyang (Institute of Theoretical Physics, Chinese Academy of Sciences); Dr CAI, Mengchu (Institute of Theoretical Physics, Chinese Academy of Sciences); Prof. YANG, Yi-Bo (Institute of Theoretical Physics, Chinese Academy of Sciences)

**Presenter:** Dr CAI, Mengchu (Institute of Theoretical Physics, Chinese Academy of Sciences)

**Session Classification:** Parallel

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **110** Type: **Oral**

# One-Point energy correlator inside jets

In this work, we introduce a new jet observable, the one-point energy correlators (EC), designed to characterize the in-jet energy flow distribution by measuring energy deposition at a specific angle relative to the jet axis. Building upon the transverse momentum dependent physics, we aim for the EC to provide novel insights into jet substructure and offer a new approach to study TMD physics, particularly gluon transverse momentum dependent fragmentation functions (TMDFFs) which are notoriously difficult to extract. We obtain the factorization of the EC jet function within Soft-Collinear Effective Theory and leverage the framework of semi-inclusive TMD fragmenting jet functions. We resum large global logarithms and non-global logarithms (NGLs) and show that the normalized EC jet function exhibits significantly reduced dependence on the factorization scale and is primarily sensitive to the jet scale. Finally, after incorporating non-perturbative effects, we present numerical calculations up to NNLL accuracy for global logarithms and LL accuracy for NGLs, and we compare these predictions with PYTHIA 8 simulations.

**Primary authors:** MI, Zihao; WANG, Zhan

**Presenter:** WANG, Zhan

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **111** Type: **Oral**

# Proton spin structure from a light-front Hamiltonian approach

I will report our recent results on proton spin structure from a light-front Hamiltonian approach. In this approach we obtain the light-front wave function of the proton through solving the eigenvalue problem of the light-front Hamiltonian of QCD in a basis based on the Fock-sector expansion. Then using the obtained light-front wave function we calculate the observables characterizing the spin structure of the proton. I will present our results on spin-dependent collinear, generalized and transverse-momentum-dependent parton distributions for the quarks and gluons in the proton. Based on these observables I will show the resulting proton spin decomposition from the light-front Hamiltonian viewpoint.

**Primary author:** ZHAO, Xingbo (Institute of Modern Physics, Chinese Academy of Sciences)

**Presenter:** ZHAO, Xingbo (Institute of Modern Physics, Chinese Academy of Sciences)

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **112** Type: **Oral**

# Spin polarization from hadrons to (anti-)(hyper-)nuclei in high-energy nuclear collisions

Particles of non-zero spin produced in non-central heavy-ion collisions are expected to be polarized along the direction perpendicular to the reaction plane because of their spin-orbit interactions in the produced matter. In this talk, I will show that the hypertriton, which is the lightest hypernucleus, is also polarized in these collisions. I will demonstrate that the polarization and decay pattern of hypertriton provides a unique tool to decipher the spin structure of hypertriton wavefunction. I will further discuss the possibility of studying the spin correlations among nucleons and Λ hyperons in the produced hadronic matter from the measured Λ polarization in non-central heavy-ion collisions.

Reference: Kai-Jia Sun et al., Phys. Rev. Lett. 134. 022301 (2025)

**Primary author:** SUN, KaiJia (Institute of Modern Physics, Fudan University)

**Presenter:** SUN, KaiJia (Institute of Modern Physics, Fudan University)

**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **113** Type: **Oral**

# Bjorken x weighted Energy-Energy Correlators from the Target Fragmentation Region to the Current Fragmentation Region

we explore the Bjorken $x$ weighted EEC in DIS from the TFR to CFR. In both regions, a factorization theorem can be derived with SCET, based on which the logarithms can be resummed to all orders in $\alpha_s$. The singular distributions can be derived from the factorized formula, which are compared against the full fixed-order QCD calculations up to NLO. Additionally, we present the resummation results up to NLL in the TFR and $N^3LL$ in the TMD region. In the extremely small angle limit, the free hadron gas model is introduced to investigate the non-perturbative distribution. We compared our predictions to partonic PYTHIA simulations. Between the hadron gas phase region and the perturbative resummation region, a transition phase is observed. The non-perturbative and hadronization effects in the TMD region were investigated by considering non-perturbative form factors extracted from the semi-inclusive hadron production in DIS. Incorporating these non-perturbative models, we also presented the comparison of our predictions to PYTHIA simulations.

**Primary authors:** Prof. LI, Haitao (Shandong University); Dr CAO, Haotian (Beijing Normal University); Mr MI, Zihao (Beijing Normal University)

**Presenter:** Mr MI, Zihao (Beijing Normal University)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions

Contribution ID: **114** Type: **Oral**

# Fragmentation Functions of Charged Hadrons at NNLO and Constraints on the Proton PDFs

We present the first global analysis of fragmentation functions (FFs) for light charged hadrons ($\pi^{\pm}$, $K^{\pm}$) at full next-to-next-to-leading order in QCD, incorporating world data from both single-inclusive electron-positron annihilation and semi-inclusive deep-inelastic scattering. The collinear factorization has been tested with low-momentum-transfer data and has demonstrated success at high hadron momenta. Additionally, we study the impact of current global data on hadron production to the parton distribution functions (PDFs), and find they favor a reduced asymmetry in the strange (anti)quark PDFs, as compared to the asymmetry predicted by state-of-the-art PDFs derived from inclusive data.

**Primary authors:** Dr SHEN, XiaoMin (Institute of Modern Physics (IMP), CAS); GAO, Jun (Shanghai Jiao Tong University); XING, Hongxi (South China Normal University); ZHAO, Yuxiang (University of Science and Technology of China (USTC)); ZHOU, Bin (Peking University)

**Presenter:** Dr SHEN, XiaoMin (Institute of Modern Physics (IMP), CAS)

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **115** Type: **Oral**

# 基于量子计算的 SU(2) 规范理论中的手性不平衡研究

We implement a variational quantum algorithm to investigate the chiral condensate in a 1+1 dimensional SU(2) non-Abelian gauge theory. The algorithm is evaluated using a proposed Monte Carlo sampling method, which allows the extension to large qubit systems. The obtained results through quantum simulations on classical and actual quantum hardware are in good agreement with exact diagonalization of the lattice Hamiltonian, revealing the phenomena of chiral symmetry breaking and restoration as functions of both temperature and chemical potential. Our findings underscore the potential of near-term quantum computing for exploring QCD systems at finite temperature and density in non-Abelian gauge theories.

**Primary authors:** 张, 国丰 (South China Normal University); 郭, 星雨; 王, 恩科; 邢, 宏喜

**Presenter:** 张, 国丰 (South China Normal University)

**Session Classification:** Parallel

Contribution ID: **116** Type: **Oral**

# Heavy vector meson production adoptingi GPD method

Exclusive heavy vector meson production is investigated in ep pp and pPb collisions employing GPD approach with GK model. Three sets gluon density are used to calculate exclusive heavy vetor meson production. The survival factors and equivalent photon approximation are applied to predict the exclusive heavy vector mesons photoproduction in proton-proton collisions. The GPD method prediction gives a good agreement with the experimental data at LHCb.

**Primary author:** XIE, Ya-Ping (Institute of modern Physics of CAS)

**Presenter:** XIE, Ya-Ping (Institute of modern Physics of CAS)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **117** Type: **Oral**

# Status of the polarized gas target for the LHCspin project

LHC at CERN is the world's highest energy collider, but it cannot accelerate polarized protons like BNL's RHIC. The LHCspin project will install a polarized hydrogen gas target in one of the accelerator rings of the LHC and use a 7 TeV proton beam and the polarized target to advance research into nucleon spin structure. In the first step, the polarized gas target and a simple particle detector will be installed at a location different from the collision point of existing experiments at the LHC, and basic polarization experiments will be performed. In the second step, the polarized gas target will be incorporated into the LHCb detector and precise polarization experiments will be performed.

The development of the polarized gas target is important for the project. Here I will show the status of the polarized target.

**Primary author:** DOSHITA, Norihiro (Yamagata University)

**Presenter:** DOSHITA, Norihiro (Yamagata University)

**Track Classification:** Polarized ion and lepton sources and targets

Contribution ID: **118** Type: **Oral**

# Total Gluon Helicity from Lattice

We use the ensemble C24P29 provided by the CLQCD collaboration, insert the topological current using the proton external state of the momentum smear under the Coulomb gauge of the 5-HYP smear, extract the matrix elements to calculate the gluon helicity under lattice QCD, and the calculation proves that different components of the topological currents ($K^z$ and $K^t$) can be used to give consistent results within the error range. In addition, we use the RI/MOM renormalization scheme, consider the mixing of gluon and quark helicity, and extract the renormalization constant to give the gluon helicity result under $\overline{\mathrm{MS}}$ scheme.

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**Presenter:** ZHAO, Dian-Jun (CUHK(Shenzhen))

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **119** Type: **Oral**

# Lattice QCD calculation of nucleon EDM

We report our lattice QCD calculation of the nucleon electric dipole moment (EDM) induced by the theta term. We use lattice chiral fermions in our calculation, which provides a fermionic definition of the topological charge exhibiting small discrete effects. Also, the use of chiral fermions guarantees a correct chiral limit even at finite lattice spacings and enables us to reliably extrapolate our result from heavy pion masses to the physical point. With the help of the cluster decomposition error reduction (CDER) technique, we have obtained so far the best results so far for the nucleon EDM.

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**Presenter:** LIANG, Jian (华南师范大学)

Contribution ID: **120** Type: **Oral**

# Effects of Spin Polarization on the Proton-Boron Reaction

In the selection of fusion fuels, proton and boron-11 as an ideal choice for commercialization due to its abundant raw materials and the absence of neutron production in the reaction. Compared with other fusion fuels, the proton-boron reaction has a smaller cross-section and requires a higher ignition temperature. To address or mitigate the impact of these difficulties, it is necessary to explore methods to enhance the nuclear reaction cross-section or improve the heating efficiency of the reaction products. Since the nuclei used in fusion reactions possess non-zero intrinsic spin angular momentum, the different spin orientations of the reactants can change the cross-section due to the constraints of angular momentum conservation. This presentation begins by discussing the advantages of selecting proton-boron as a candidate in the magnetic confinement fusion, as well as the challenges we will encounter during its application. To realize the proton-boron fusion reaction, we list several methods that could be employed to reduce the ignition requirements required for proton-boron reactions. Nuclear spin polarization as a potential method, which is considered in the report and the influence of nuclear spin orientation on the cross-section is also explored.

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**Session Classification:** Parallel

**Track Classification:** Application of spin and nuclear polarization techniques

Contribution ID: **121** Type: **Oral**

# Equivalence principle and shear in exclusive and inclusive processes

The structures related to shear and shear viscosity may appear in the expansion of energy-momentum tensor (EMT) in various processes.Such terms in various channels may be related either to naive T-oddness (like for Single Spin Asymmetries) or exotic quantum numbers. Their presence is constrained by the equivalebnce principle (EP) which holds exactly (in the forward limit) in the case of conserved EMT and approximately (justifuying the Extension of EP) for the contributions of separate quarks and gluons.
The approximate validity of ExEP may be related to smallness of shear viscosity observed in various theoretical approaches. The relevant observables in exclusive and inclusive hadronic processes as well as in Heavy-Ion Collisions are discussed.

**Primary author:** TERYAEV, Oleg (JINR)

**Presenter:** TERYAEV, Oleg (JINR)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **122** Type: **Oral**

# Quantum simulations of non-perturbative quantities in hadron scattering

In this presentation, I will discuss our exploratory work on simulating non-perturbative QCD quantities relevant to hadron scattering processes using quantum computing methods. This includes mapping lattice gauge field theories to qubits, simulating parton distribution functions (PDFs), Light-cone distribution amplitudes, and Fragmentation functions on a quantum computer.

**Primary author:** TIANYIN, Li (RIKEN)

**Presenter:** TIANYIN, Li (RIKEN)

**Track Classification:** Quantum computing and artificial intelligence

Contribution ID: **123** Type: **Oral**

# Gravitational form factors from light front QCD

The energy-momentum tensor encodes the internal energy, spin, and stress distributions within hadrons, shedding new light on hadron structures and fundamental QCD problems such as confinement and the origin of hadron mass. In recent years, it has become possible to measure this quantity directly from experiments via generalized parton distributions, leading to growing interest in both experimental and theoretical studies. However, the dynamical nature of this observable poses a significant challenge, particularly for strongly coupled hadrons.

In this talk, I will discuss our recent progress in investigating the energy-momentum tensor and the associated gravitational form factors based on a nonperturbative light-front Hamiltonian approach. Our main result is a general, nonperturbative light-front wave function representation, which provides an adequate microscopic description. This representation is derived from a strongly coupled (3+1)-dimensional scalar field theory and is renormalized with a Fock sector-dependent scheme. It can be applied to various systems, including the charmonia, the pion, and the nucleon, with their respective light-front wave functions, offering new insights into the strong force within hadrons.

**Primary authors:** CAO, Xianghui (University of Science and Technology of China); LI, Yang (University of Science and Technology of China); Prof. VARY, James (Iowa State University); WANG, Qun (University of Science and Technology of China); MONDAL, Chandan (Institute of Modern Physics); Dr GURJAR, Bheemsehan (Indian Institute of Technology Kanpur)

**Presenter:** CAO, Xianghui (University of Science and Technology of China)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **124** Type: **Oral**

# Recent Developments in perturbative calculations on DVCS

Deeply virtual Compton scattering (DVCS) is established as the golden channel for accessing generalized parton distributions (GPDs), which encode the nucleon's three-dimensional structure and are crucial for understanding the origin of nucleon spin. In this talk, I will summarize recent theoretical advances in predicting the DVCS process to higher perturbative orders. These developments are essential for analyzing upcoming high-precision measurements from the JLab 12 GeV upgrade, EIC, and EIcC, with the ultimate goal of precision nucleon GPD determination.

**Primary author:** JI, Yao

**Presenter:** JI, Yao

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **125** Type: **Oral**

# Relativistic dynamics of charmonia in strong magnetic fields

In this talk, I present our recent investigation of charmonium systems in strong external magnetic fields using a relativistic light-front Hamiltonian approach within the basis light-front quantization (BLFQ) framework. By solving the eigenvalue problem for the invariant mass squared operator —incorporating confinement potentials and one-gluon-exchange interactions —we compute the mass spectrum and wave functions across varying magnetic field strengths. Our results reveal significant spectral modifications driven by the Zeeman effect, including $\eta_c$-$J/\psi$ mixing and splitting of magnetic sublevels. Analysis of the momentum density distributions shows pronounced wave function deformation: transverse momentum broadening and longitudinal compression in strong fields, along with notable structural changes in parton distribution profiles —such as the emergence of double-hump structures in excited states. We find that relativistic corrections and center-of-mass coupling play a crucial role in these dynamics, underscoring the necessity of a fully relativistic treatment for accurately describing QCD bound states in extreme electromagnetic environments and vorticity.

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**Presenter:** LI, Yang (University of Science and Technology of China)

**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **127** Type: **Oral**

# hadronic tensor in (1+1)-dimensional systems by quantum computing

The hadronic tensor encodes key information about the internal structure of hadrons, reflecting the non-perturbative features of quantum chromodynamics (QCD). We perform a direct computation of the hadronic tensor in (1+1)-dimensional $U(1)$ and $SU(2)$ gauge theories by evaluating the real-time current-current correlation function using proposed quantum algorithms implemented on classical hardware. We demonstrate that the elastic form factor can be reliably extracted from the hadronic tensor, with results showing good agreement with those obtained via exact diagonalization.

**Primary authors:** ZOU, Dairui (South China Normal Universi); LI, Tianyin (South China Normal University); XING, Hongxi (South China Normal University)

**Presenter:** ZOU, Dairui (South China Normal Universi)

Contribution ID: **128** Type: **Oral**

# Nucleon energy correlators as a probe for light-quark dipole operators at the EIC

In this talk, we propose nucleon energy correlators (NECs) as a novel framework to probe electroweak light-quark dipole operators in unpolarized deep-inelastic scattering. These operators encode chirality-flipping interactions and typically appear quadratically in unpolarized processes. We construct a chiral-odd quark NEC that accesses quark transverse spin via azimuthal asymmetries in the energy flow of the target fragmentation region. We demonstrate that these asymmetries serve as clean and powerful observables for linearly constraining the quark dipole couplings. Unlike existing methods, our approach avoids the need for polarized nucleon beams or particle identification, relying solely on inclusive calorimetric measurements. This work represents one of the first applications of energy correlator observables to new physics searches and offers a robust path to precision studies of chirality-violating effects at the electron-ion collider.

**Primary authors:** Dr TONG, Xuanbo; Dr HUANG, Yingsheng; 王, 昊琳 (SCNU)

**Presenter:** 王, 昊琳 (SCNU)

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **129** Type: **Oral**

# ePIC at the upcoming EIC

The Electron-Ion Collider (EIC), scheduled to commission in the early 2030s, will be the world's first facility that collides a polarized electron beam with a polarized proton beam as well as ion beams. The collider will be built at the Brookhaven National Lab (BNL). The Electron-Proton/Ion Collider (ePIC) is a general purpose detector to be built at the six-o'clock interaction point (IP6) of the accelerator ring. With EIC's high luminosity beams and the $4\pi$ coverage of the detector setup, ePIC will be able to take large statistics polarized scattering measurements over a wide range of kinematics including regions that have not yet been explored. The detector is designed to answer many important and long-existing questions in nuclear physics, including the spin crisis of proton, origin of nucleon mass and gluon saturations. In this presentation, an overview of the ePIC detector system will be given, and highlights of the potential science programs will be discussed.

**Primary author:** LIN, Win (Stony Brook University)

**Presenter:** LIN, Win (Stony Brook University)

**Session Classification:** Parallel

**Track Classification:** Future facilities and experiments

Contribution ID: **130** Type: **Oral**

# Nucleon Structure from Basis Light-Front Quantization : Status and Prospects

We report recent advancements in understanding nucleon structure within the Basis Light-Front Quantization (BLFQ) framework—a fully relativistic, nonperturbative approach to solving quantum field theories. Starting with the leading Fock sector $|qqq\rangle$ and an effective light-front Hamiltonian incorporating confinement and one-gluon exchange, BLFQ has successfully described key nucleon observables. The framework has since been extended to include the next-to-leading Fock sector $|qqqg\rangle$, enabling studies of gluonic contributions to the nucleon's internal structure, including gluon helicity, orbital angular momentum, and three-dimensional imaging through GPDs and TMDs. Most recently, BLFQ has achieved a significant milestone by computing nucleon light-front wavefunctions as eigenstates of the QCD Hamiltonian without an explicit confining potential. These calculations, including Fock sectors up to $|qqqq\bar{q}\rangle$, allow towards first-principles predictions of quark and gluon matter densities, helicity and transversity distributions, and spin observables, showing qualitative agreement with experimental and phenomenological results. Together, these developments highlight BLFQ' s growing capacity to provide an increasingly complete and realistic picture of nucleon structure grounded in QCD.

**Primary author:** MONDAL, Chandan (Institute of Modern Physics)

**Presenter:** MONDAL, Chandan (Institute of Modern Physics)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: generalized parton distributions and form factors

Contribution ID: **132** Type: **Oral**

# Color-field induced spin transport in high-energy nuclear collisions

Despite the successful description of global polarization of $\Lambda$ hyperons in heavy ion collisions through thermal voricity, the follow-up observations of local spin polarization and spin alignment of vector mesons further indicate the presence of additional mechanisms upon spin transport of quarks in the QCD medium. In high-energy nuclear collisions, the soft thermal gluons in the quark gluon plasma phase or the overpopulated gluons in the glasma phase as its precursor in the color-glass-condensate effective theory may be delineated by fluctuating chromo-electromagnetic fields (or color fields for short). By employing the recently developed quantum kinetic theory of quarks with phenomenological models and approximations, we study the momentum dependence for dynamical spin alignment of $\phi$ mesons from longitudinally dominant color fields in the glasma phase. Also, the non-dynamical spin alignment coming from soft thermal gluons characterized by isotropic color fields in the quark gluon plasma is qualitatively analyzed for comparison. Moreover, we investigate how color-field correlators along with anisotropic quark flow could generate local spin polarization from the corona of the glasma, which may play a significant role on longitudinal polarization of $\Lambda$ hyperons particularly in small collision systems.

**Primary author:** YANG, Di-Lun (Academia Sinica)

**Presenter:** YANG, Di-Lun (Academia Sinica)

**Session Classification:** Parallel

**Track Classification:** Spin in heavy ion collisions

Contribution ID: **134** Type: **Oral**

# The nucleon structure from an AdS/QCD model in the Veneziano limit

We employ the VQCD model, a holographic approach that dynamically simulates essential QCD characteristics, including linear mass spectra, confinement, asymptotic freedom, and magnetic charge screening, while incorporating quark flavor effects. Using this model, we first calculate the proton mass spectrum and the wave function, incorporating anomalous dimensions to refine our results. Next, we compute the proton structure functions across a range of Bjorken x values using consistent parameters. Furthermore, we derive the proton electromagnetic form factor by solving the equation of motion for electromagnetic field, accounting for background effects, and demonstrate
qualitative consistency with results from free electromagnetic fields coupled to fermions. Finally, we calculate the gravitational form factors by introducing an effective graviton mass m arising from
chiral symmetry breaking and the proton energy-momentum tensor. Our calculations yield results that are in excellent agreement with experimental data and lattice QCD computations, validating the VQCD model as a robust tool for studying proton properties.

**Primary author:** HOU, Defu (CCNU)

**Co-author:** Mr DENG, Jiali

**Presenter:** HOU, Defu (CCNU)

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **135** Type: **Oral**

# Helicity Dependent Distribution Functions of the proton and Λ and Σ0 Baryons

Using continuum Schwinger function methods, a coherent set of predictions for proton, Λ and Σ0 baryons is delivered - both helicity dependent and unpolarised. The analysis reveals impacts of diquark correlations and SU(3)-flavour symmetry breaking, some of which are significant. For instance, were it not for the presence of axialvector diquarks in the Σ0, the strange quark could carry none of the Σ0 spin. The discussion will canvass issues that include helicity retention in hard scattering processes; the sign and size of polarised gluon DFs; and the origin and decomposition of baryon spins.

**Primary author:** ROBERTS, Craig (Nanjing University)

**Presenter:** ROBERTS, Craig (Nanjing University)

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **136** Type: **Oral**

# The Production and Decay Dynamics of the Charmed Baryon $\Lambda_c^+$ in $e^+e^-$ Annihilations near Threshold

The study of the charmed baryons is crucial for investigating the strong and weak interactions in the Standard Model and for gaining insights into the internal structure of baryons. In an $e^+e^-$ experiment the lightest charmed baryon, $\Lambda_c^+$, can be produced in pairs through the single photon annihilation process. This process can be described by two complex electromagnetic form factors. The presence of a non-zero relative phase between these form factors gives rise to a transverse polarization of the charmed baryon and provides additional constraints on the dynamic parameters in the decays. In this article, we present the first observation of the transverse polarization of $\Lambda_c^+$ in the reaction $e^+e^- \to \Lambda_c^+\bar{\Lambda}_c^-$, based on $6.4\mathrm{fb}^{-1}$ of $e^+e^-$annihilation data collected at center-of-mass energies between 4600 MeV and 4951 MeV with the BESIII detector. The decay asymmetry parameters and strong phase shift in the decays $\Lambda_c^+ \to pK_S^0, \Lambda\pi^+, \Sigma^0\pi^+, \Sigma^+\pi^0$ are also simultaneously extracted from the joint angular distributions. These results are vital for understanding $CP$ violation and its role in the matter-antimatter asymmetry of the Universe.

**Primary authors:** Dr SUN, Hao (UCAS); Dr WANG, Hongjian (Lanzhou University); Dr HAN, Kunlin (University of Chinese Academy of Sciences); Prof. LI, Peirong (Lanzhou University); Prof. PING, Ronggang (IHEP); MA, Hailong (IHEP); Prof. LYU, Xiao-Rui (University of Chinese Academy of Sciences); ZHENG, Yangheng (University of Chinese Academy of Sciences)

**Presenter:** Dr SUN, Hao (UCAS)

**Track Classification:** Fundamental symmetries and spin physics beyond the standard model

Contribution ID: **140** Type: **Oral**

# Proton PDFs and fragmentation functions

By treating the proton as a quark + interacting-diquark bound state, whose structure is obtained by solving a Poincare covariant Faddeev equation, we provide a comprehensive, coherent set of predictions for unpolarised and polarised proton parton distribution functions (DFs): valence, glue, and four-flavour separated sea. The results address many things including the origin of the proton spin. Then by exploiting the crossing symmetry, the corresponding fragmentation functions (FFs) can be calculated. The obtained FFs are compared with the existing fits, which are very useful for the future data analyses.

**Primary authors:** XING, Hui-Yu (Nanjing University); CHENG, Peng (Anhui Normal University); YU, Yang (Nanjing University)

**Co-author:** ROBERTS, Craig (Nanjing University)

**Presenter:** XING, Hui-Yu (Nanjing University)

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **141** Type: **Oral**

# Perspective on proton polarised parton distribution functions

Supposing there exists an effective charge which defines an evolution scheme for both unpolarised and polarised parton distribution functions (DFs) that is all-orders exact and using Ansätze for hadron-scale proton polarised valence quark DFs, constrained by flavour-separated axial charges and insights from perturbative quantum chromodynamics, predictions are delivered for all proton polarised DFs. The pointwise behaviour of the predicted DFs and, consequently, their moments, compare favourably with results inferred from data.

**Primary author:** Dr CHENG, Peng (Anhui Normal University)

**Presenter:** Dr CHENG, Peng (Anhui Normal University)

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **143** Type: **Oral**

# Recent progress on inclusive quarkonium production and polarization

Quarkonium production and polarization serves as a vital testing ground for quantum chromodynamics (QCD), offering critical insights into both perturbative and nonperturbative dynamics. In the nonrelativistic QCD (NRQCD) factorization framework, inclusive production cross sections of quarkonia are expressed as products of perturbatively calculable short-distance coefficients (SDCs) and nonperturbative long-distance matrix elements (LDMEs), which are hypothesized to be universal across production processes. For three decades, the validation of LDME universality has been central to understanding quarkonium production mechanisms. However, different groups extracted dramatically different sets of the three color-octet LDMEs of J/\psi, and none of them can describe all the production and polarization data from LHC, HERA, LEP and Belle, challenging the universality of LDMEs. In this talk, we will report our recent progress on factorizing the LDMEs into products of wave functions and gluonic correlators based on the potential NRQCD (pNRQCD) effective theory and comprehensive phenomenogical study on inclusive quarkonium prduction and polarization. We show that most of the data can be well described in the framwork of NRQCD factorization and those still evade a consistent discription coincide with "extenstions" of endpoint regions.

**Primary author:** WANG, Xiangpeng (CCNU)

**Presenter:** WANG, Xiangpeng (CCNU)

**Session Classification:** Parallel

**Track Classification:** Nucleon helicity structure

Contribution ID: **144** Type: **Oral**

# Exploring Short-Range Correlations (SRC) in Nuclei through Hadronic Probes at JINR

Short-Range Correlations (SRC) emerge when a proton and neutron within a nucleus come into close proximity - at distances comparable to the nucleon radius - forming a high-momentum, strongly interacting pair. This phenomenon offers a unique window into the transition region between two descriptions of nuclear matter: the low-resolution picture of nuclei as systems of protons and neutrons, and the high-resolution view governed by quark and gluon degrees of freedom.

Over the past decade, electron scattering experiments have established SRCs as a key feature of nuclear structure, influencing nucleon-nucleon interactions, nuclear binding, and many-body dynamics. Building on these insights, the Joint Institute for Nuclear Research (JINR, Russia) has initiated a dedicated program to study SRCs via hadron-hadron interactions, providing complementary information to that obtained from electron scattering.

This program employs GeV/nucleon-energy ion beams impinging on a cryogenic liquid hydrogen target, optimized for probing SRCs through hard quasi-elastic knockout reactions in inverse kinematics. These reactions selectively probe single nucleons or correlated nucleon pairs with high internal momenta and allow reconstruction of nuclear fragments and their momentum distributions. Following two successful experimental runs with a carbon-12 beam, the next phase, reported here, will utilize a tensor-polarized deuteron beam, aiming to unravel spin-dependent aspects of SRC dynamics and deepen our understanding of the underlying nuclear forces.

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**Presenter:** PATSYUK, Maria (Joint Institute for Nuclear Research)

**Session Classification:** Parallel

**Track Classification:** Future facilities and experiments

Contribution ID: **145** Type: **Oral**

# Application of nuclear covariance matrix in nuclear TMD effects

In this work, we investigate the nuclear modification effects in transverse momentum dependent (TMD) observables by implementing a nuclear covariance matrix in the treatment of theoretical uncertainties. Global QCD analysis is performed with the aforementioned nuclear covariance matrix to verify its equivalence with the traditional approach of including a nuclear correction parameter. The data analyzed are the Drell-Yan $q_T$-differential data in $pA$ and $\pi A$ collisions. In addition, we also perform global QCD analysis with no treatment for the nuclear effects, verifying the necessity of implementing the nuclear corrections.

**Primary authors:** SIGNORI, Andrea (University of Turin and INFN); ZHOU, Yiyu (University of Turin); NOCERA, Emanuele Roberto (Università degli Studi di Torino and INFN Torino); Prof. BOGLIONE, Mariaelena (University of Turin); Dr BARRY, Patrick (Argonne National Lab)

**Presenter:** ZHOU, Yiyu (University of Turin)

**Session Classification:** Parallel

**Track Classification:** Three-dimensional structure of the nucleon: transverse momentum dependent parton distributions