Sar WorS 2019 - Sardinian Workshop on Spin studies

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Cittadella dei Musei

Book of Abstracts

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Probing gluon TMDs through quarkonia production

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In the last years a big progress has been made in the quark sector of TMDs, but the gluon sector is so far much less developed, due to the difficulty to cleanly probe gluons in high-energy processes. A very promising way to access them, but also challenging, is through quarkonia production. However, a solid theoretical framework is still lacking.
In this talk I will present new developments towards a new formalism which, based on the effective field theory approach, allows to establish the needed factorization theorems to properly access gluon TMDs in quarkonia production.

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Describing unpolarized SIDIS data at order α_s

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I will discuss a view on the issues of describing unpolarised SIDIS data in their entire spectrum, as well as possible solutions.

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TMDs studies with fixed-target collisions at LHCb

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Fixed-target pp and pA collisions with a proton beam at the TeV scale provide unique laboratories for the study of the nucleon's internal dynamics and, more in general, for the investigation of the complex phenomena arising in the non-perturbative regime of QCD. Due to the substantial boost of the reaction products in the laboratory frame, fixed-target collisions allow to access the poorly explored backward center-of-mass rapidity region, corresponding to the high x-Bjorken and high negative x-Feynman regimes. Thanks to its forward acceptance and its outstanding performances, the LHCb detector at the LHC is perfectly suited for the reconstruction of particles produced in fixed-target collisions at √sNN = 110 GeV. The LHCspin project aims to bring both polarized and unpolarized physics at the LHC through the installation of a gaseous fixed target at the upstream end of the LHCb detector. In particular, the use of transversely polarized H and D targets will allow to study the quarks TMDs in single-polarized Drell-Yan at unique kinematic conditions (high-x at moderately-high Q2). Furthermore, thanks to the LHCb high reconstruction capabilities for particles containing heavy quarks, access to the essentially unknown polarized and unpolarized gluons TMDs will be possible through the study of inclusive quarkonia or heavy-mesons production. An overview

of the possible TMDs studies to be performed with polarized and unpolarized fixed-target collisions at LHCb is presented.

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TMDs from SIDIS data: role of different choices in phenomenological analyses

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In this talk we will assess the role of the different choices on TMD functions parametrisations in phenomenological analyses.

As an example, the latest Sivers extraction from SIDIS data is presented. Motivated by the latest COMPASS measurement, a new, thorough study of uncertainties affecting the extracted quark Sivers function, along with a critical assessment of visibility of TMD signals in SIDIS data, has been performed. We will see that, even within a simple and transparent parametrisation, a satisfactory description of experimental data is obtained.

Finally, a preliminary study on transversity function and its impact on the tensor charge will be discussed.

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Linearly Polarized Gluon Distribution in J/psi Production at the EIC

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We calculate the cos 2φ asymmetry in J/ψ production in electron-proton collision for the kinematics of the planned electron-ion collider (EIC). This directly probes the Weisz¨acker-Williams (WW) type linearly polarized gluon distribution. Assuming generalized factorization, we calculate the asymmetry
at next-to-leading-order (NLO) when the energy fraction of the J/ψ satisfies z < 1 and the dominating subprocess is γ∗ + g ⟶ c + ¯c + g. We use non-relativistic QCD based color singlet (CS) model for J/ψ
production. We investigate the small x region which will be accessible at the EIC. We present the upper bound of the asymmetry, as well as estimate it using a (i) Gaussian type parametrization for the
TMDs and (ii) McLerran-Venugopalan (MV) model at small x. We find small but sizable asymmetry in all the three cases.

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Kinematical analysis of non-collinearity

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The Drell-Yan process and electron-positron annihilation offer a natural arena for studies of non-collinearity. We [1] show how covariantly defined variables for these processes and also for semi-inclusive deep inelastic scattering are suited to get a feeling for the magnitude of intrinsic tranverse momenta.

[1] P.J. Mulders and C. Van Hulse ArXiv:1903.11467 [hep-ph]

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Improving the perturbative accuracy of TMD PDF extractions: preliminary results

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In this contribution we present our recent preliminary results on the extraction of the unpolarised transverse-momentum dependent (TMD) parton distribution functions (PDFs) from a study of Drell-Yan and Z-boson production data. We consider a wide dataset that includes low-energy data from the FNAL and high-energy data from Tevatron and the LHC. In particular, we highlight the challenges of including the most recent LHC data and theoretical uncertainties in the analysis.

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Transverse-momentum-dependent gluon distribution in a spectator model

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While significant steps toward the formal definition of quark TMDs and their extraction from experimental data through global fits has been made in the last years, the gluon-TMD field represents a largely unexplored territory. Pursuing the goal of extendending our knowledge of this sector, we present analytic expressions for all T-even gluon TMDs at twist-2, calculated in a spectator model for the parent nucleon. At variance with respect to previous works, our approach encodes a flexible parametrization for the spectator-mass spectral density, allowing us to improve the description in the small-x region. We build a common framework where valence, sea quark and gluon densities are concurrently generated. Our results can be used to predict the behavior of observables sensitive to gluon-TMD dynamics.

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Effect of flavor-dependent partonic transverse momentum on precision measurements at hadron colliders

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The electroweak working group at the LHC is actively working to analyse (and, possibly, reduce) all kind of theoretical and experimental uncertainties affecting precision electroweak observables. The resummation of soft and collinear radiation to all orders has a considerable impact on selected observables (i.e. mW). I will first present a concise review of the different frameworks (SCET, TMD, qt resummation, parton branching) presently available to take into account this kind of effect. Then, I will give an overview of recent results concerning the impact of a possible flavour dependence of the intrinsic quark transverse momentum on the direct determination of the boson mass. I will show that these effects are comparable in size to other nonperturbative effects commonly included in phenomenological analyses and should thus be included in precise theoretical predictions for present and future hadron colliders.

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Hadro-production of Z-bosons in the Parton Branching Approach to TMDs

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Transverse Momentum Dependent (TMD) parton distributions obtained from the Parton Branching (PB) method are combined with next-to-leading-order (NLO) calculations of Drell-Yan (DY) production. We apply the MC-at-NLO method for the hard process calculation and matching with the PB TMDs. We compute predictions for the transverse momentum, rapidity and phi-* spectra of Z bosons. We find that the theoretical uncertainties of the predictions are dominated by the renormalization and factorization scale dependence, while the impact of TMD uncertainties is moderate. The theoretical predictions agree well, within uncertainties, with measurements at the Large Hadron Collider (LHC). In particular, we study the region of lowest transverse momenta at the LHC, and comment on its sensitivity to nonperturbative TMD contributions.

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Gluon TMDs in J/psi + jet production at an EIC

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The process e + p -> e + J/psi + jet + X, where the proton can be polarized, is computed in the transverse momentum-dependent (TMD) factorization framework. This framework is applicable in the regime where the J/psi - jet pair is produced almost back-to-back in the transverse plane, such that its total transverse momentum is a measure of the primordial k_t of the parton. We show that in the kinematical regime of our interest, and at the energies of the planned Electron-Ion Collider (EIC), the contribution of the quark channel is strongly suppressed, such that the cross section can be analyzed solely in function of gluon TMDs. We demonstrate how these gluon TMDs could be disentangled using the various azimuthal asymmetries in the cross section, and comment on the influence of the different production mechanisms of the quarkonium (Color Singlet Model vs Non-Relativistic QCD) on our results.

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Single-Spin Asymmetry in J/ψ Production in Proton-Proton Collision

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Among the eight leading twist gluon TMDs, gluon Sivers function (GSF) has been the limelight in hadron physics. GSF is not yet known fully, though attempts have been made. The J/ψ production has been advertised to probe the gluon TMDs. In this talk, we present the calculation of single-spin asymmetry (SSA) in $pp^{\uparrow} \to J/\psi + X$ process to probe the unknown GSF within the generalized parton model (GPM) framework. The non-relativistic QCD (NRQCD) framework is employed for calculating color singlet and color octet states of J/ψ. Finally, we compare the unpolarized differential cross section with PHENIX and CDF data in the low P_T region.

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The 3D nucleon structure program at JLab

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In the recent years, it has been realized that in DIS reactions, single and dihadron semi-inclusive and hard exclusive production, provide a variety of spin and azimuthal angle dependent observables sensitive to the dynamics of quark-gluon interactions. New parton distributions and fragmentation functions have been introduced to describe the rich complexity of the hadron structure and move towards a multi-dimensional imaging of the underlying parton correlations. Besides the hard probe scale, these functions explicitly depend on the parton transverse degrees of freedom at the scale of confinement. Studies of the parton distribution functions which encode transverse momentum (TMDs) or transverse position (GPDs) promise to open a unprecedented gateway to the unique dynamics of the strongly interacting force. This work presents a selection of available observations and upcoming measurements planned at Jefferson Lab to address the mysteries of the nucleon structure from a modern point of view.

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The impact of the errors of collinear functions in describing unintegrated SIDIS data.

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Describing qT-dependent SIDIS distributions requires consideration of two different regimes which involve two different factorization schemes. In both cases, the necessary ingredients include parton distribution and fragmentation functions (PDFs and FF), which are traditionally extracted in statistical analyses with collinear observables. In this talk I will present examples of how the errors in the extraction of collinear PDFs and FFs may affect the successful description of the qT-dependent SIDIS distributions.

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Transverse Λ polarisation in e^+e^- collisions

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We discuss how recent data from the Belle Collaboration on transverse Λ polarisation measured in e^+e^- annihilation processes could be used to extract, for the first time, the polarising fragmentation function. This, giving the probability that an unpolarised parton fragments into a transversely polarised spin-1/2 hadron, represents one of the 8 leading-twist transverse momentum dependent fragmentation functions. Preliminary results will be shown.

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COMPASS studies of TMDs; recent results and future perspectives

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COMPASS is a fixed target experiment in operation at CERN since 2002 with a wide physics programme. An important part of this programme is the study of transverse spin and momentum dependent parton distribution and fragmentation functions. A review of recent results on TMDs obtained using both muon or hadron beams scattering off unpolarised and polarized targets will be given. The future 2021 approved run with a muon beam scattering off a transversely polarized deuteron target, as well as the further future plans of the COMPASS++/AMBER Collaboration will also be discussed.

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Hadron production in electron-positron annihilation

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Fragmentation functions, describing the formation of hadrons from partons, are an indispensable tool in the interpretation of hadron-production data, e.g., in the investigation of nucleon structure via semi-inclusive deep-inelastic scattering. The cleanest process to access fragmentation functions is hadron production in electron-positron annihilation. In this review a selection of recent results on hadron production in electron-positron annihilation will be discussed, supplemented with an outlook on what can be expected in the nearer future.

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Recent results on Quarkonia at forward rapidity with ALICE at the LHC

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ALICE is the experiment specifically designed for the study of the Quark-Gluon Plasma (QGP) in heavy-ion collisions at the CERN LHC. Heavy-ion collisions help us to understand quarkonium suppression and regeneration mechanisms in the presence of the QGP. However, a modification of heavy quarkonium production can also take place in proton-nucleus collisions, where a QGP is not expected to be created and only cold nuclear matter (CNM) effects, such as nuclear absorption, parton shadowing and parton energy loss in initial and final states occur. The study of proton-nucleus collisions is therefore important to disentangle the effects of QGP from the CNM ones, and to provide essential input to understand nucleus-nucleus collisions. Finally, proton-proton collisions give insight to the different quarkonium production mechanisms and provide the baseline for the nuclear modification factor of quarkonium production in proton-nucleus and nucleus-nucleus collisions.
ALICE has produced a large amount of results on quarkonia both at forward and mid rapidity at various energies and colliding systems (pp, p-Pb, Pb-Pb and Xe-Xe) during the LHC Run1 and Run2 periods. In this talk, recent results on multiplicity dependent study of quarkonia in pp and p-Pb collisions will be discussed. Latest ALICE results of quarkonium nuclear modification factor, elliptic flow and polarization using the 2018 Pb-Pb data sample will also be presented. The results will be compared with other LHC results and theoretical predictions.

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Improving the perturbative accuracy of TMD PDF extractions: formalism

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Closing