Report on the theme 02-0-1085-2009/2023 (COMPASS project) for the period 2021-2022

In 2021-2022, the JINR group in the COMPASS experiment successfully participated in a run with a muon beam with momentum of 160 GeV/c, scattered off a transversely polarized ^{6}LiD target. The data obtained will complete the work on the study of quark contributions to the transverse spin structure of the nucleon. During the run, the JINR team ensured stable operation of subsystems of the COMPASS setup, such as the MW1 scattered muon identification system and the HCAL1 hadron calorimeter. It should be noted that the detectors were started up after a long shutdown due to the COVID19 pandemic and the rescheduling of the run. In addition, the JINR team, as a whole, has fulfilled its obligations for shifts at the COMPASS setup.

In 2021-2022, the analysis of data collected in previous years was continued. The following results were obtained with the direct involvement of the JINR team:

Probing transversity by measuring Λ polarisation in SIDIS

Based on the studies of the target-transverse-spin asymmetries in single-hadron and hadron-pair production in Semi-Inclusive measurements of Deep Inelastic Scattering (SIDIS), the chiral-odd transversity quark distribution functions h^{q}_{1} are nowadays well established. Several possible channels to access these functions were originally proposed. One candidate is the measurement of the polarisation of Λ hyperons produced in SIDIS off transversely polarised nucleons, where the transverse polarisation of the struck quark might be transferred to the final-state hyperon (Fig.1).

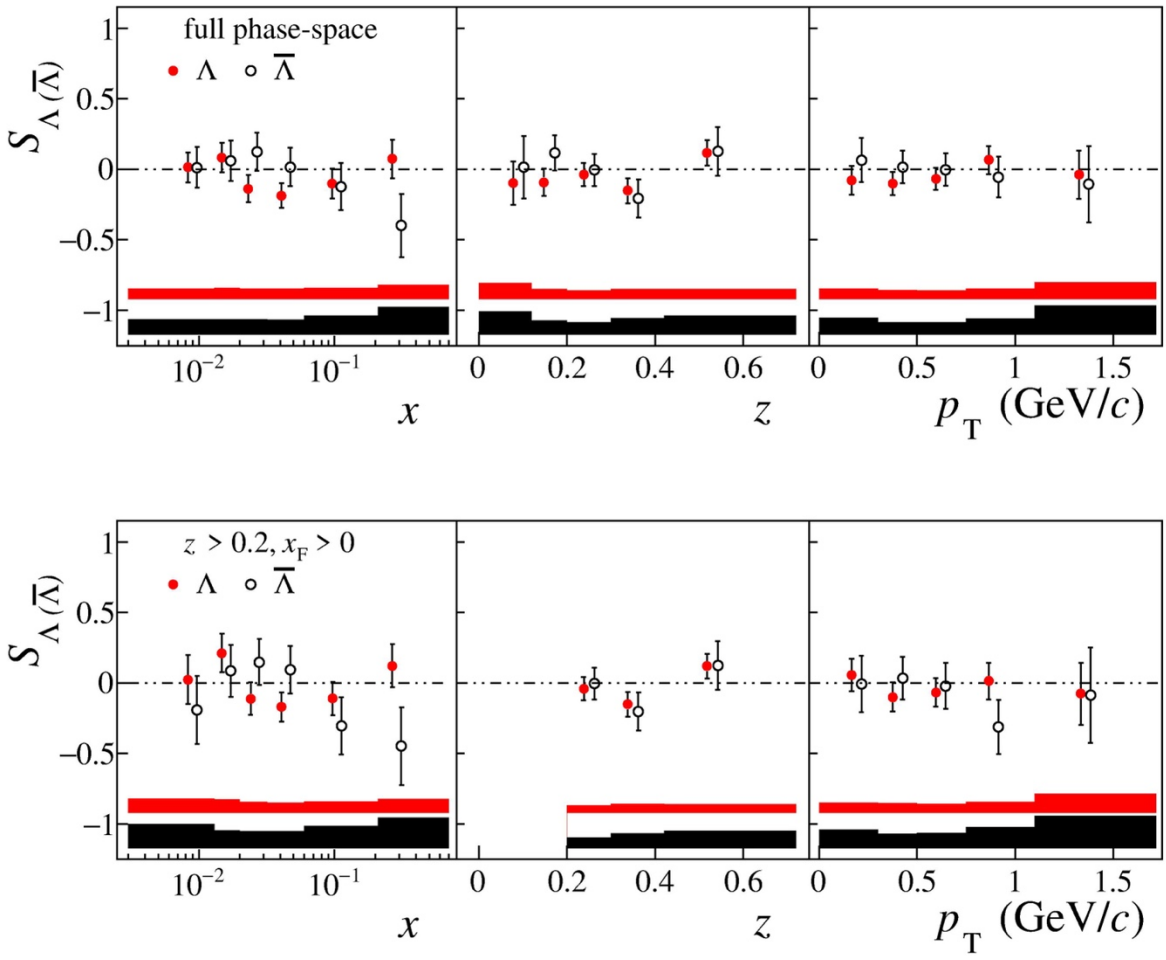

Figure 1: Spin transfer for the full phase-space (top) and for the current fragmentation region (bottom), as a function of x, z and P_T .

In this study, the results are presented on the transversity-induced polarisation of Λ and Λ hyperons produced in SIDIS off transversely polarised protons. Within the experimental uncertainties, no significant deviation from zero was observed [2] (Fig.2).

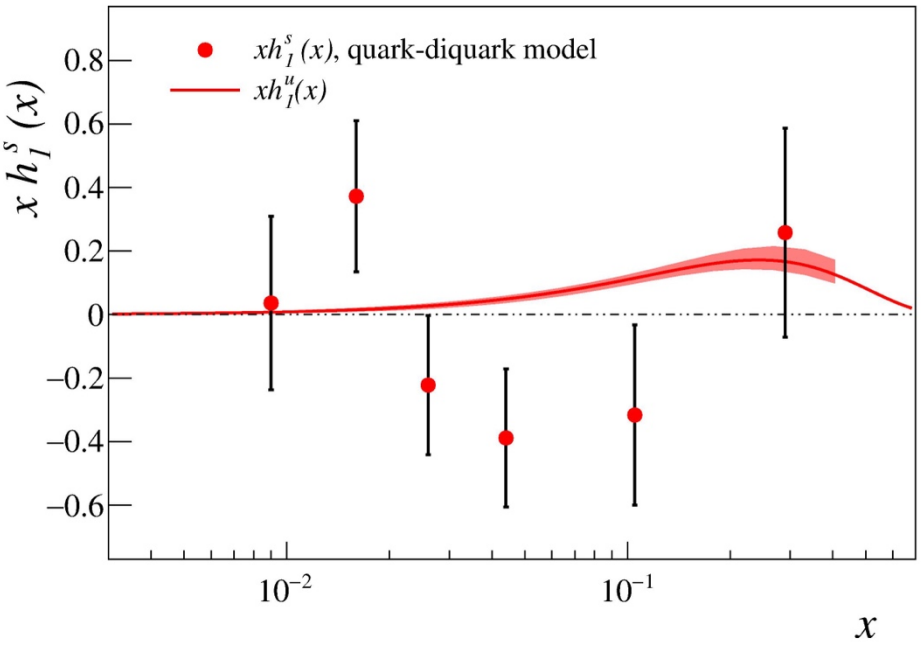

Figure 2: Extracted values of $xh^s{}_1(x)$ according to a quark-diquark model. The u quark transversity curve is given for comparison.

The exotic meson π_1 (1600) with $J^{PC} = 1^{-+}$ and its decay into ρ(770)π

COMPASS collaboration has performed the studies the spin-exotic $J^{PC} = 1\,-+$ amplitude in single-diffractive dissociation of 190 GeV/c pions into $\pi - \pi - \pi +$ using a hydrogen target [6]. One was confirmed the π_1 (1600) → ρ(770)π amplitude, which interferes with a nonresonant 1^{-+} amplitude. It was demonstrated that conflicting
conclusions from previous studies on these amplitudes can be attributed to different analysis models and different treatment of the dependence of the amplitudes on the squared four-momentum transfer and we thus reconcile their experimental findings. One was studied the nonresonant contributions to the $\pi - \pi - \pi +$ final state using pseudo-data generated on the basis of a Deck model (Fig.3). Subjecting pseudo-data and real data to the same partial-wave analysis, we find good agreement concerning the spectral shape and its dependence on the squared four-momentum transfer for the $J^{PC} = 1^{-+}$ amplitude and also for amplitudes with other J^{PC} quantum numbers. One was investigated for the first time the amplitude of the π− π+ subsystem with $J^{PC} = 1^{--}$ in the 3π amplitude with $J^{PC} = 1^{-+}$ employing the novel freed-isobar analysis scheme. We reveal this π−π+ amplitude to be dominated by the ρ(770) for both the π_1 (1600) and the nonresonant contribution. We determine the ρ(770) resonance parameters within the three-pion final state (Fig.4). These findings largely confirm the underlying assumptions for the isobar model used in all previous partial-wave analyses addressing the $J^{PC} = 1^{-+}$ amplitude.

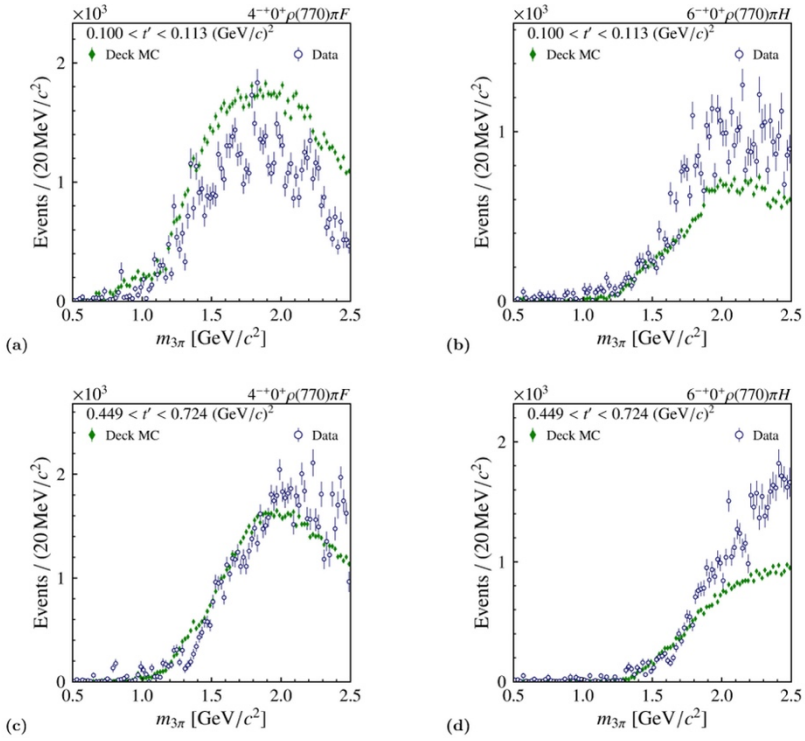

Figure 3: Intensity distributions of the 4-+0+ρ(770)πF wave (left column) and the 6-+0+ρ(770) πH wave (right column) . The real data are represented by the blue data points; the Deck pseudo data by the green data points.

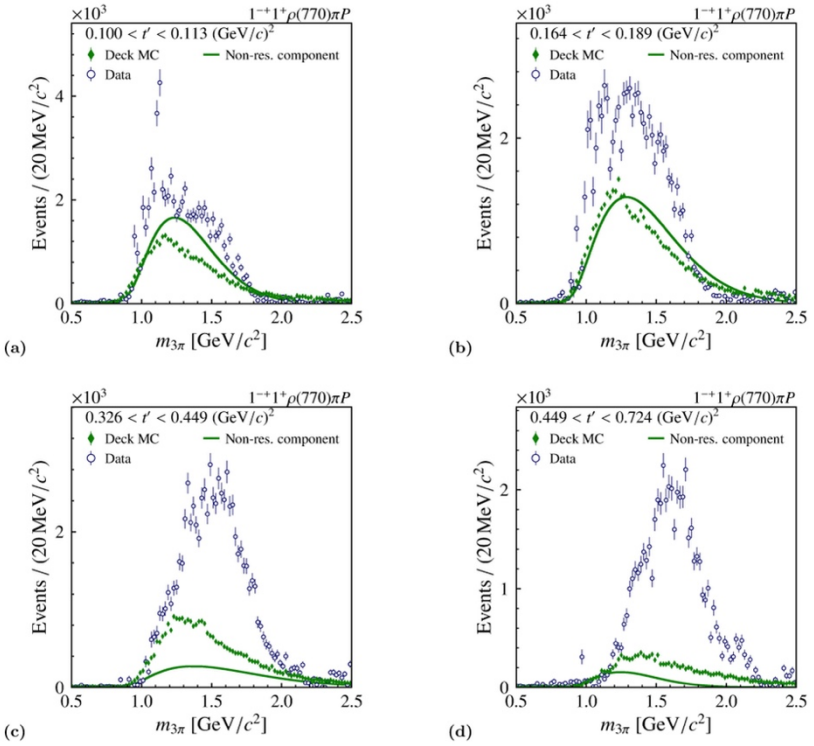

Figure 4: Intensity distributions of the 1-+1+ρ(770)πP . The real data are represented by the blue data points; the Deck pseudo data by the green data points. The green curve represents the nonresonant component determined in the resonance-model [7].

The JINR group obtained a preliminary results for the Longitudinal double-spin asymmetry in the exclusive production of ρ^0-meson from proton and deuteron COMPASS data and for the $F_{3\pi}$ coupling constant from the exclusive reaction $\pi^- A \to \pi^- \pi^0 A$.

The important result for the transverse-spin-dependent azimuthal asymmetries in the pion-induced J/ψ production was obtained (see Figure) from 2015 and 2018 Drell-Yan data. In general all TSAs are found to be small and compatible with zero within the experimental errors.

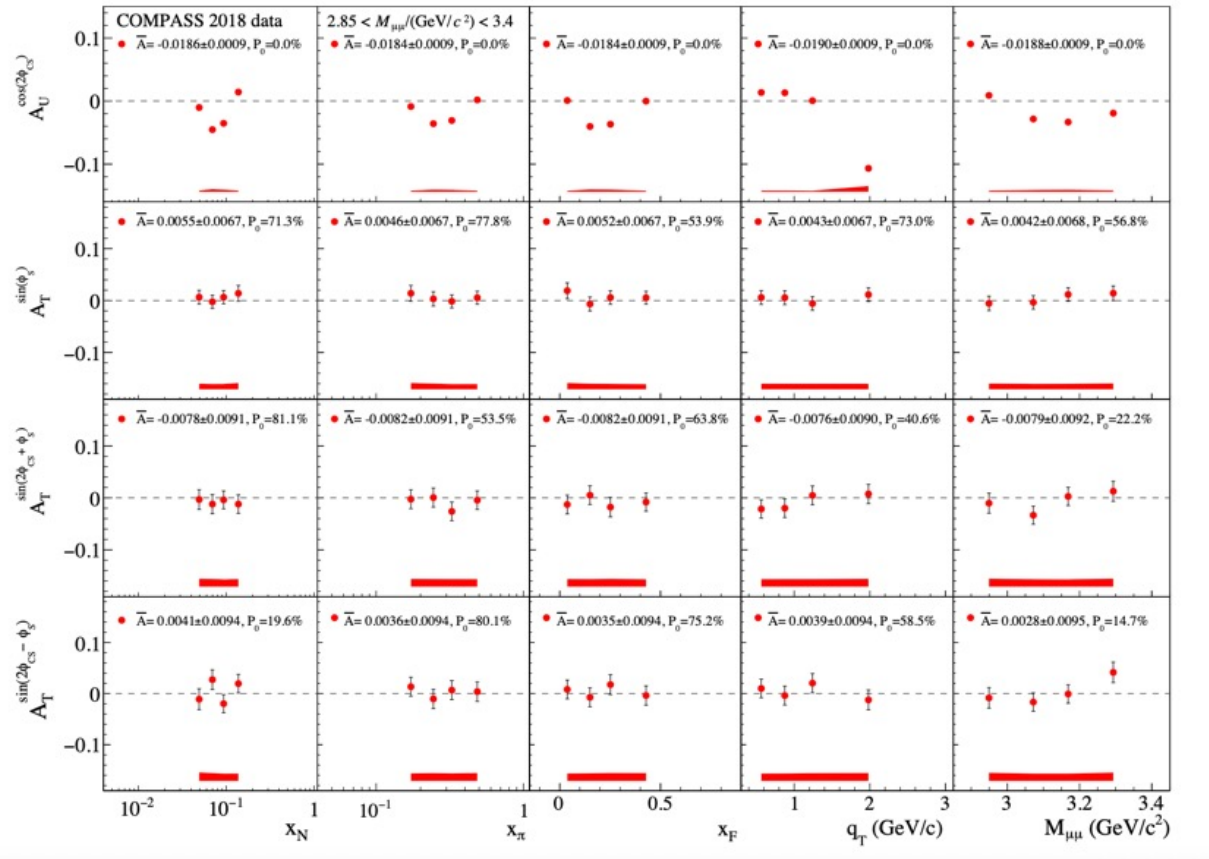

Figure 5: SSA in pion induced J/ψ production

Double J/ψ production in pion-nucleon scattering

The inclusive double J/ψ production is studied by the COMPASS experiment using a pion beam scattering off various nuclear targets. The differential cross section is measured as a function of $M_{2J/\psi}$, $x_{\|\,2J/\psi}$, $p_{T\,2J/\psi}$ and $\Delta x_{\|}$. No evidence of any resonant states decaying into two J/ψ is found within the limited statistics of this measurement. To discriminate the leading production mechanism, the differential cross section $d\sigma_{2J/\psi}/dx_{\|\,2J/\psi}$ is used since contributions from IC and SPS mechanisms are expected to peak in different $x_{\|\,2J/\psi}$ regions. Both SPS and IC hypotheses are used to fit $d\sigma_{2J/\psi}/dx_{\|\,2J/\psi}$. The upper limit on the production rate of double J/ψ from the intrinsic charm mechanism is estimated. The obtained result for the differential cross section $d\sigma_{2J/\psi}/dx_{\|\,2J/\psi}$ is fully consistent with the SPS hypothesis which

appears to be sufficient to describe the data. Within estimated uncertainties the contribution of intrinsic charm is found to be small and compatible with zero.

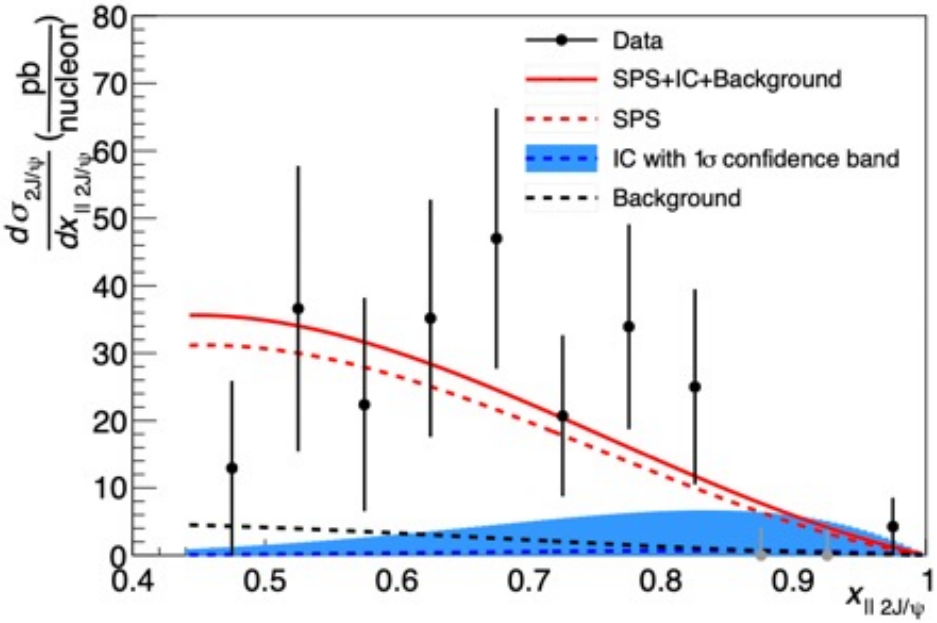

Figure 6: The cross section of double J/ψ production per nucleon as a function of the double J/ψ longitudinal momentum fraction, $x_{\parallel 2J/\psi}$

Within the Theme 1085 we continues preparing a proposal to participate in the new AMBER project (NA66) at the SPS accelerator beam at CERN. The goal of the project is to study the emergence of hadron masses through understanding the structure and properties of mesons and baryons.

In the reporting, the JINR group made 6 reports at international conferences, published 3 papers and sent 3 to the journal. One master's thesis has been defended, one PhD defense is expected in 2023.