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Studies of the Nucleon and Hadron Structure at CERN
NA-58 Collaboration

Theme 02-0-1085-2009/2022

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Studies of the Nucleon and Hadron Structure at CERN

Project COMPASS-II, theme 02-0-1085-2009/2022,
Extension for 2021-2022

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1. INTRODUCTION.

COMPASS is a high-energy physics experiment at the Super Proton Synchrotron (SPS) at CERN in Geneva, Switzerland. The purpose of this experiment is the study of hadron structure and hadron spectroscopy with high intensity muon and hadron beams.

On February 1997 the experiment was approved by CERN and the final Memorandum of Understanding was signed in September 1998. The spectrometer was installed in 1999–2000 and commissioned during a technical run in 2001. The physics experiments started in summer 2002 with a muon beam and polarised proton and deuteron targets. These semi-inclusive deep inelastic scattering (SIDIS) experiments reveal details of the quark-gluon structure of the nucleon, in particular the gluon polarisation and transverse-momentum-dependent correlations. After the shutdown in 2005, COMPASS resumed the SIDIS experiments in 2006 and 2007 with a new large-aperture target magnet. The spin structure measurements were continued in 2010 and 2011.

The years 2008 and 2009 were dedicated to the hadron spectroscopy programme with pion and proton beams scattering off a liquid hydrogen target and nuclear targets. An unprecedented amount of data was collected and has allowed for a much refined analysis of the final states, and is still revealing subtle details of the light-meson spectrum. Part of 2009 was dedicated to the study of the pion polarisability using Primakoff scattering of pions from heavy nuclei. This measurement had been prepared by a pilot run in 2004. The programme was continued in 2012 under COMPASS phase-II.

The COMPASS-II proposal [1], suggested by the same Collaboration as continuation of COMPASS project, has been approved in May, 2010, and the corresponding theme at JINR was prolonged up to 2020.

COMPASS-II is primarily dedicated to the transverse and 3D structure of nucleons using Deeply Virtual Compton scattering (DVCS), Hard Exclusive Meson Production (HEMP), SIDIS and polarised Matveev-Muradyan-Tavkhelidze or Drell-Yan (further - DY) reactions. Approved in 2010, it started in 2012 with a Primakoff run and a DVCS pilot run using a muon beam and a long liquid hydrogen target with a huge recoil detector. The first-ever polarised Drell-Yan measurement with a beam of negative pions and a polarised proton target was successfully performed in 2015 and the data taking was resumed in 2018. The years 2016 and 2017 were dedicated to DVCS measurement and simultaneously data on HEMP and SIDIS were collected.

For 2021 after long shut-down, further measurements of SIDIS off transversely polarised deuterons were approved.

This extension of the COMPASS-II project is the last one, in the future, the project is planned to close and continue the analysis of COMPASS-II data within the JINR theme activity.

2. RESULTS OF THE PREVIOUS STAGE OF THE PROJECT (2018-2020).

In 2018, COMPASS-II continued the data taking for the program of studying parton distributions that depend on the transverse parton momentum in DY processes with a pion beam at energy of 160 GeV and with a polarized target. The JINR group actively participated in the preparation of the setup and in the data taking. It is important to note the tasks that are done with the active participation of JINR physicists and engineers: maintenance of the hadron calorimeter (HCAL1), coordinate detector systems (MW1), support for the polarized target, support for the data acquisition system (DAQ), the engineering structure of the experimental hall, and analysis of the experimental data.

In 2018-2020, the analysis of data obtained in 2002-2017 was continued. During the reporting period, the collaboration prepared and published 10 articles. Three articles were prepared with significant contributions from JINR physicists.

First measurement of transverse-spin-dependent azimuthal asymmetries in the Drell-Yan process

The first measurement of transverse-spin-dependent azimuthal asymmetries in the DY processes was done by COMPASS with usage the CERN SPS 190 GeV/c π^- beam and a transversely polarized ammonia target. Three azimuthal asymmetries giving access to different transverse-momentum-dependent (TMD) parton distribution functions (PDFs) are extracted using dimuon events with invariant mass between 4.3 $(GeV/c)^2$ and 8.5 $(GeV/c)^2$. The observed sign of the Sivers asymmetry (Fig. 1, top panel) is found to be consistent with the fundamental prediction of QCD that the Sivers TMD PDFs extracted from DY have a sign opposite to the one extracted from semi-inclusive deep-inelastic scattering (SIDIS) data, as one shown in Fig. 2. Two other asymmetries originating from the pion Boer-Mulders TMD PDFs convoluted with either the nucleon transversity or pretzelosity TMD PDFs are also extracted from data (see Fig. 1, middle and bottom panels). These DY results are obtained at a scale comparable to that of a recent COMPASS SIDIS measurement and hence allow unique tests of fundamental QCD universality predictions (Fig. 2). The results of these measurements are published by the collaboration in [2].

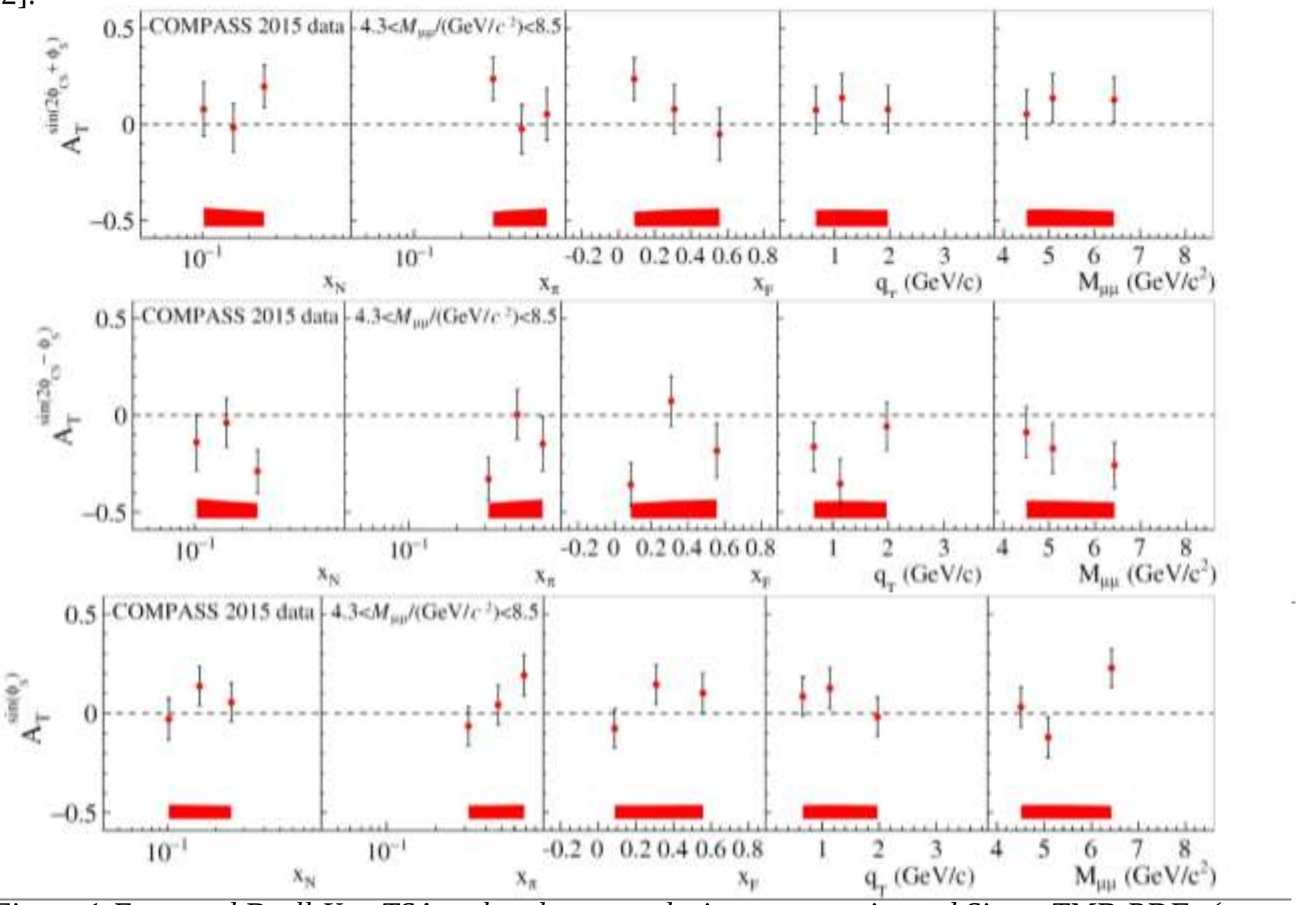

Figure 1:Extracted Drell-Yan TSAs related to pretzelosity, transversity and Sivers TMD PDFs (top to bottom).

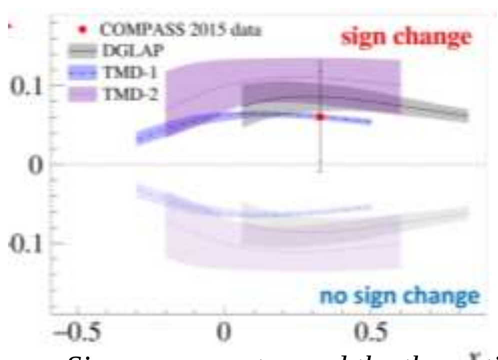

Figure 2: The measured mean Sivers asymmetry and the theoretical predictions for different Q^2 evolutions approaches.

First measurement of the Sivers asymmetry for gluons from SIDIS data

The Sivers function describes the correlation between the transverse spin of a nucleon and the transverse motion of its partons. It was extracted from measurements of the azimuthal asymmetry of hadrons produced in semi-inclusive deep inelastic scattering of leptons off transversely polarized nucleon targets, and it turned out to be non-zero for quarks. In this letter the evaluation of the Sivers asymmetry for gluons in the same process is presented. The analysis method is based on a Monte Carlo simulation that includes three hard processes: photon-gluon fusion, QCD Compton scattering and leading-order virtual-photon absorption process. The Sivers asymmetries of the three processes are simultaneously extracted using the LEPTO event generator and a neural network approach. The method is applied to samples of events containing at least two hadrons with large transverse momentum from the COMPASS data taken with a 160 GeV/c muon beam scattered off transversely polarized deuterons and protons. With a significance of more than two standard deviations a negative value is obtained for the gluon Sivers asymmetry. The result of a similar analysis for a Collins-like asymmetry for gluons is consistent with zero. The results of these measurements are published by the collaboration in [3].

K − over K + multiplicity ratio for kaons produced in DIS with a large fraction of the virtual-photon energy

The K − over K + multiplicity ratio is measured in deep-inelastic scattering, for the first time for kaons carrying a large fraction z of the virtual-photon energy. The data were obtained by the COMPASS collaboration using a 160 GeV muon beam and an isoscalar ^{6}LiD target. The regime of deep-inelastic scattering is ensured by requiring Q 2 > 1 (GeV/c) 2 for the photon virtuality and W > 5 GeV/c ^{2} for the invariant mass of the produced hadronic system. Kaons are identified in the momentum range from 12 GeV/c to 40 GeV/c, thereby restricting the range in Bjorken-x to 0.01 < x < 0.40. The z-dependence of the multiplicity ratio is studied for z > 0.75, one is shown in Figures 3 and 4. For very large values of z, i.e. z > 0.8, the results contradict expectations obtained using the formalism of next-to-leading order perturbative quantum chromodynamics. This may imply that cross-section factorisation or/and universality of (kaon) fragmentation functions do not hold. Our studies suggest that within this formalism an additional correction may be required, which takes into account the phase space available for hadronisation.

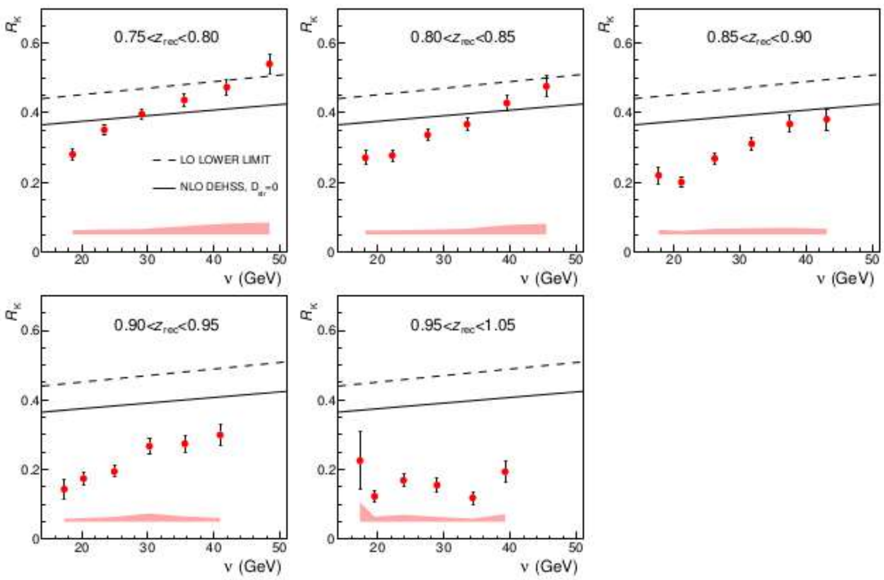

Figure 3:The K − over K + multiplicity ratio as a function of ν in bins of z, shown for the first bin in x. QCD predictions are given in solid and dashed lines.

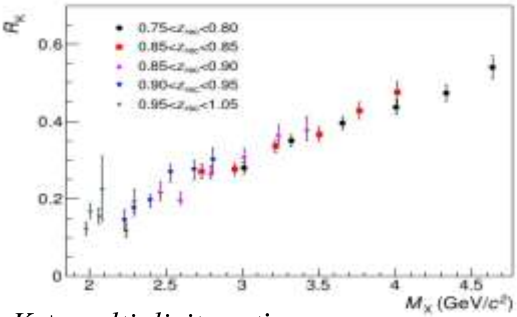

Figure 4: The K − over K + multiplicity ratio .

The results of these measurements are published by the collaboration in [4].

Transverse Extension of Partons in the Proton probed by Deeply Virtual Compton Scattering

For first time COMPASS-II has performed the measurements of exclusive single-photon muoproduction on the proton using 160 GeV/c polarized $\mu +$ and $\mu -$ beams of the CERN SPS impinging on a liquid hydrogen target. One has determined the dependence of the average of the measured $\mu +$ and $\mu -$ cross sections for deeply virtual Compton scattering on the squared four-momentum transfer t from the initial to the final proton. The slope B of the t-dependence is fitted with a single exponential function for range $0.1 - 2\ (\mathrm{GeV/c})^2$ (Fig.5) which yields

$$B = (4.3 \pm 0.6_{\mathrm{stat}} \, {}^{+\,0.1}_{-\,0.3}\big|_{\mathrm{sys}})\,(\mathrm{GeV}/c)^{-2}$$

This result can be converted into an average transverse extension of partons in the proton,

$$\sqrt{\langle r_\perp^2 \rangle} = (0.58 \pm 0.04_{\mathrm{stat}} \, {}^{+\,0.01}_{-\,0.02}\big|_{\mathrm{sys}})\,\mathrm{fm}$$

for the average virtuality of the photon $\langle Q^2 \rangle = 1.8\ (\mathrm{GeV/c})^2$ and the average value of the Bjorken variable equal to $x_{Bj} = 0.056$.

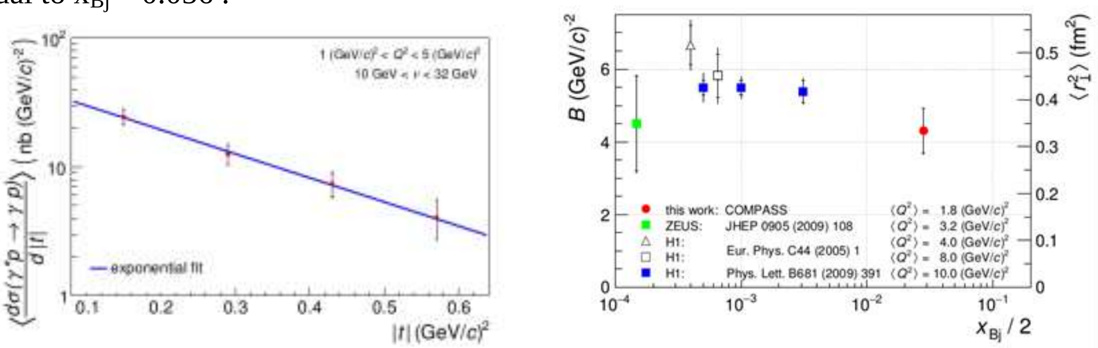

Figure 5: Differential DVCS cross section as a function of |t|(left). The results of measurements of the t-slope of parameter B, and, accordingly, the average squared transverse extension of partons in the proton, as a function of x_{Bj} /2.

The results of these measurements are published by the collaboration in [5].

Search for muoproduction of X(3872) at COMPASS and indication of a new state tilde-X(3872)

The searching for exclusive production of exotic charmonia in the reaction $\mu + N \rightarrow \mu + (J/\psi\pi^+\pi^-)\pi^\pm N$ was performed using COMPASS data collected with incoming muons of 160 GeV/c and 200 GeV/c momentum. In the $J/\psi\pi^+\pi^-$ mass distribution we observe a signal with a statistical significance of 4.1 σ, one is shown in Figure 6. Its mass and width are consistent with those of the X(3872). The shape of the $\pi + \pi -$ mass distribution from the observed decay into $J/\psi\pi + \pi -$ shows disagreement with previous observations for X(3872). The observed signal may be interpreted as a possible evidence of a new charmonium state, spectra is given in Figure 7. It could be associated with a neutral partner of X(3872) with C = −1 predicted by a tetraquark model. The product of cross section and branching fraction of the decay of the observed state into $J/\psi\pi^+\pi^-$ is determined to be 71±28(stat)±39(syst) pb. The results of these measurements are published by the collaboration in [6].

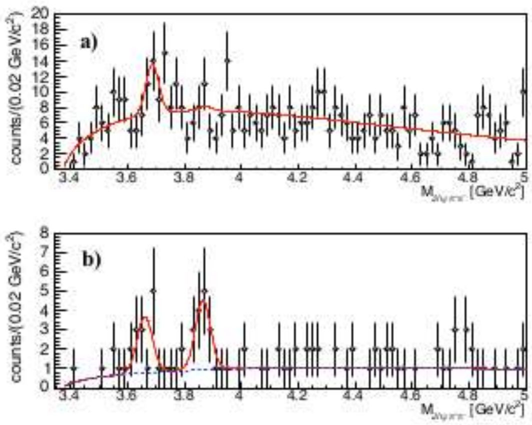

Figure 6: The $J/\psi\pi^+\pi^-$ invariant mass distributions for the $J/\psi\pi^+\pi^-\pi^\pm$ final state (two entries per event) for non-exclusive events (−12 GeV < ΔE < −4 GeV) and (b) for exclusive events (−4 GeV < ΔE < 4 GeV) with missing mass M_{miss} above 3 GeV/c^2 .

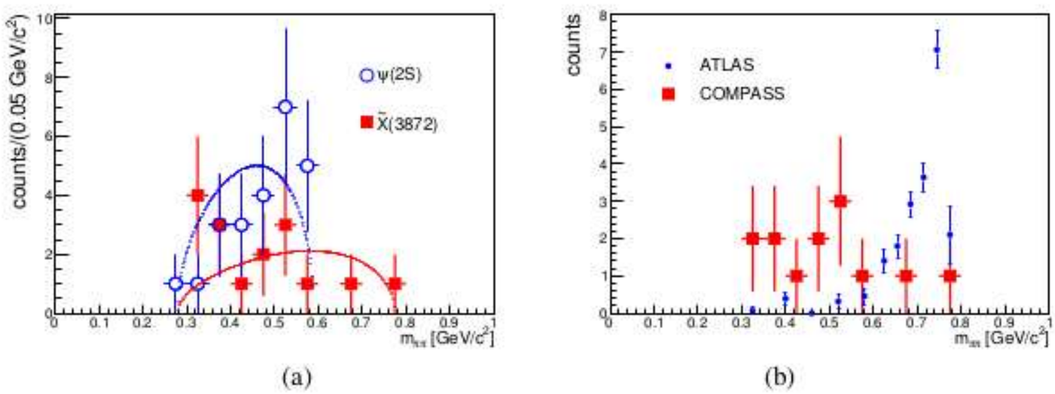

Figure 7: (a) Invariant mass spectra for the $\pi^+\pi^-$ subsystem from the decay of X(3872) (red squares) and ψ(2S) (blue circles). (b) Invariant mass spectra for the $\pi^+\pi^-$ subsystem from the decay of X(3872) measured by COMPASS with the applied cut M_{miss} > 3 GeV/c^2 (red squares) and from the decay of X(3872) observed by ATLAS (blue points).

Search for pion-induced double J/ψ production

Ongoing interest to the production J/ψ pair in hadronic interaction of is caused by a general problem of understanding of charmonia production mechanisms and possibility to form a tetraquark that decays into a J/ψ pair. At low energies the single-parton scattering (SPS) is the main contributor to the production of double charmonia while the double-parton scattering (DPS) could be responsible for a few percent of contribution. In contrast to high-energy experiments where gluon-gluon fusion production mechanism dominates, the dominant mechanism should be the quark-antiquark annihilation. The hypothesis of intrinsic charm introduced S. Brodsky (BHPS approach) assumes the presence of a non-negligible Fock components with c-cbar pairs in hadron. The intrinsic charm of pion could also be responsible for the production of double charmonia.

COMPASS observed pion-induced double J/ψ production off nuclear targets and determined the cross sections of the reaction. The obtained result for the differential cross section is fully consistent with the SPS production mechanism, Figure 8 shows this result . An upper limit of the relative contribution of the intrinsic charm production mechanism could be estimated. No evidence of any resonant states decaying into the two J/ψ final state was found.

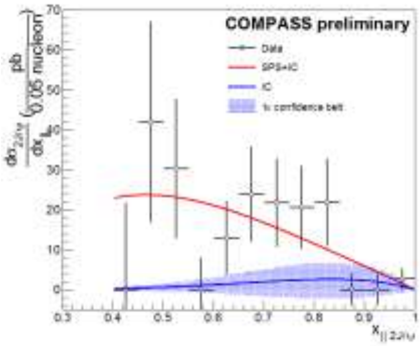

Figure 8: The differential cross section of the double J/ψ production. Contributions of the intrinsic charm and single parton scattering mechanisms are shown.

Azimuthal asymmetries of charged hadrons produced in high-energy muon scattering off longitudinally polarised deuterons

Single hadron azimuthal asymmetries in the cross sections of positive and negative hadron production in muon semi-inclusive deep inelastic scattering off longitudinally polarised deuterons are de-termined using the 2006 COMPASS data and also all deuteron COMPASS data. For each hadron charge, the dependence of the azimuthal asymmetry on the hadron azimuthal angle φ is obtained by means of a five-parameter fitting function that besides a φ -independent term includes four modulations predicted by theory: sin φ , sin 2φ , sin 3φ and cos φ . The amplitudes of the five terms have been first extracted for the data integrated over all kinematic variables, Fugure 9 shows these results. In further fits, the φ -dependence is determined as a function of one of three kinematic variables (Bjorken-x, fractional energy of virtual photon taken by the outgoing hadron and hadron transverse momentum), while disregarding the other two. Except the φ -independent term (Fig.10), all the modulation amplitudes are very small, and no clear kinematic dependence could be observed within experimental uncertainties. The results of these measurements are published by the collaboration in [7].

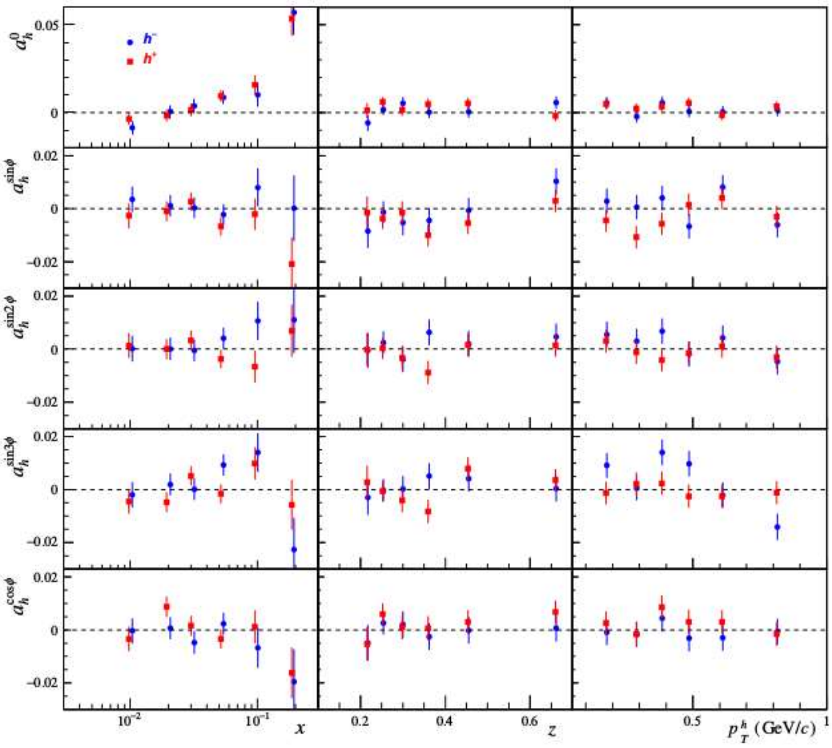

Figure 9: The modulation amplitudes of the h+ and h− azimuthal asymmetries as a function of x , z and $p^h{}_T$ obtained from the combined 2002–2006 data on the muon SIDIS off longitudinally polarised deuterons. Only statistical uncertainties are shown.

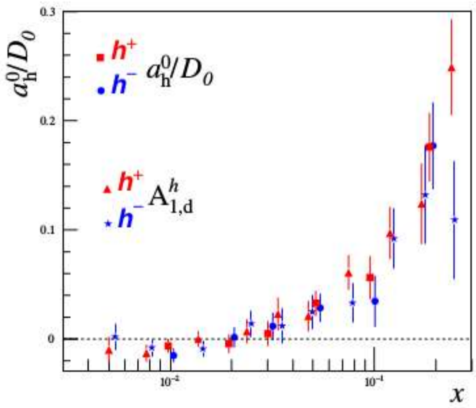

Figure 10: The x-dependences of the $a^0{}_{h\pm}/ D_0(x, y)$ values for 2002–2006 data in comparison with the data of $A^h{}_{1,d}$ obtained by COMPASS.

3. COMPASS-II IN 2020-2022.

To continue research of TMDs COMPASS-II prepared a proposal [8] to extend SIDIS measurements in 2021. This proposal was approved by CERN SPSC in 2018.

The study of the transverse spin structure of nucleons is one of the most important topics of recent theoretical and experimental research in the field of high-energy physics. A good knowledge of the dependencies of parton distributions on the transverse momentum of the parton and the relationship of this dependence to the spins of the parton is necessary for understanding the orbital motion of the parton and moving towards a more structured picture that goes beyond the collinear representation of the parton distributions. In QCD, for the leading twist, the nucleon structure is described by eight parton distributions that depend on the parton's transverse proper momentum (TMDS): $F_1(x, k^2_T)$, $g_1{}^L(x, k^2_T)$, $H_1(x, k^2_T)$, $g_1{}^T(x, k^2_T)$, $h_1{}^T(x, k^2_T)$, $h_1{}^L(x, k^2_T)$, $h_1(x, k^2_T)$, и $f_1{}^T(x, k^2_T)$.

One of the main methods for investigating the above-mentioned parton distributions is to measure semi-inclusive deep-inelastic scattering processes of polarized leptons on polarized nuclear targets. Such measurements are the most important point of the physical program of the COMPASS and COMPASS-II experiments. The data taking periods for this topic were performed in 2002-2004, 2007, and 2010 with polarized targets.

The main experimental aims of such measurements are the following:
- measurement of the Collins and Sivers asymmetries;
- getting data on the parton distribution of h_1 (transversity);
- measurement of the tensor charge;
- getting new data on the g_2 structure function;
- measurement of asymmetries in processes with the two hadrons production;
- exclusive vector mesons production.

In the SIDIS cross-section asymmetries they are convoluted with fragmentation functions (FFs) [9, 10], and can be extracted from the data using independent information on the FFs. Particularly interesting is the measurement of the SIDIS cross-section when the target nucleon is transversely polarised. In this domain the HERMES and the COMPASS Collaborations have performed pioneering measurements at different beam energies (27 and 160 GeV respectively) and shown beyond any doubt the correctness of three most interesting recent conjectures (Fig. 11):
- The Sivers function $f^{\perp}_{1T}$: in a nucleon that is polarised transversely to its momentum the quark distribution is not left-right symmetric with respect to the plane defined by the directions of the nucleon spin and momentum. This asymmetry of the distribution function is called the Sivers effect, and the asymmetric function is known as the Sivers PDF [11].
- The transversity distribution function h_1: the quarks in a transversely polarized nucleon are transversely polarized. Their polarization is described by the h_1 PDFs which a priori are different and have different properties from the helicity PDFs.

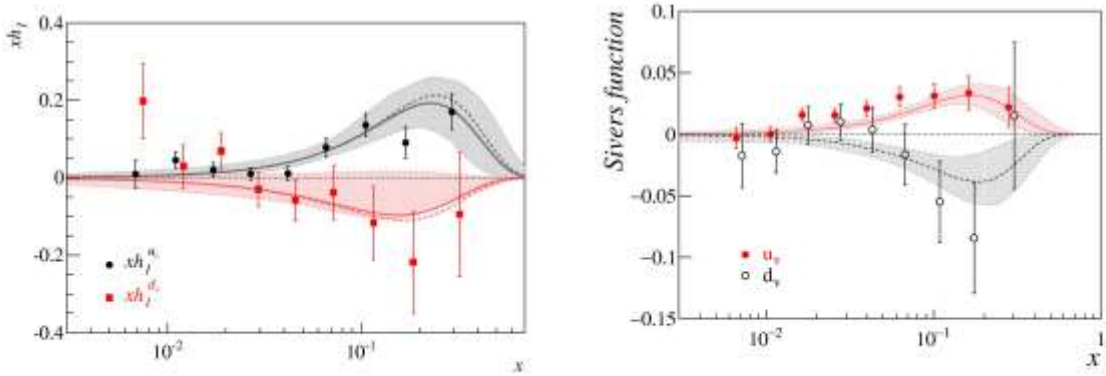

Figure 11: The transversity and Sivers PDFs extracted point-by-point using the existing COMPASS p and d data from Ref. [12] and [13]. The curves are the results of fits to the COMPASS and HERMES data and, for transversity, to the Belle data. Note that the uncertainty band for the d-quark transversity would be larger if the Soffer bound was not imposed.

- The Collins function $H^{\perp}_{1}$: the hadronization of a transversely polarised quark is not left-right symmetric with respect to the plane defined by the direction of the quark momentum and the quark spin. This fact has been confirmed by the e+e− measurements at Belle, BaBar and BES and has been exploited to measure the quark transversity PDFs. The previous results of the COMPASS collaboration are shown in Figure 12.

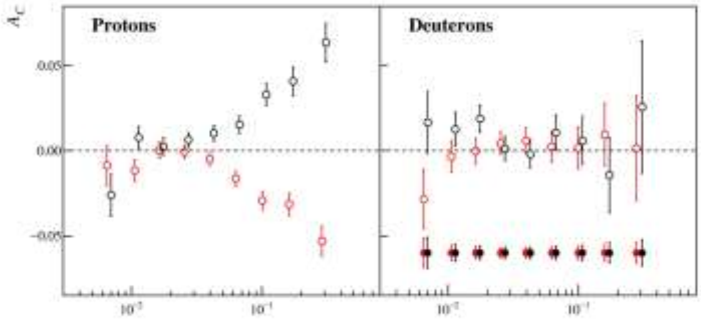

Figure 12: The Collins asymmetry A_C obtained from the 2010 data with the polarized proton NH_3 target as a function of x (left plot) compared to the results we obtained from the runs of 2002, 2003 and 2004 with polarized deuteron ^6LiD target (right plot). The red (black) points refer to positive (negative) hadrons. The full points at −0.06 in the right plot show the extrapolated statistical error from the proposed deuteron run.

COMPASS-II plans to perform a standard one-year data taking, studying the scattering the M2 muon beam with 160 GeV/c momentum on a transversely polarised deuteron target.

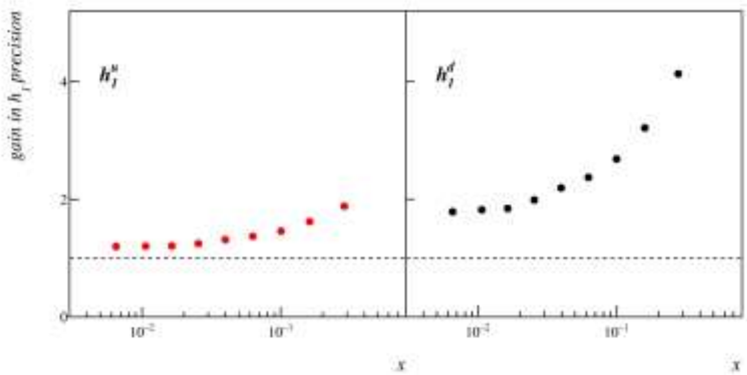

Figure 13: Ratio of the existing uncertainties on the extracted transversity and the projected uncertainties for u_v-quark (left) and d_v-quark (right).

The impact of the proposed measurement is quantified in Fig. 13, which gives the ratio, at each x value, of the present and projected errors on the extracted transversity PDFs. The gain in precision for the d-quark ranges from a factor of 2 at small x to more than a factor of 4 at large x, and is also important for the u-quark. Since in all our measurements the systematic uncertainties are a small fraction of the statistical ones here they are neglected.

The apparatus to be used for the deuteron run is basically the COMPASS Spectrometer as it was used in the 2010 muon run. One is shown schematically in Fig. 14. This implies removing the absorber which will be used for the 2018 Drell-Yan run, moving the polarized target 2 m downstream to the position it had for the SIDIS runs, and reinstalling all the trackers and all the counters which were used in 2010. The polarised target will be housed in the large acceptance COMPASS PT magnet, and the target material will be the same which was used in the years 2002, 2003, 2004 and 2006, namely ^{6}LiD. For a better usage of the muon beam, the target cells diameter will be increased from 3 to 4 cm. The average polarisation of the target is expected to be the same as in the past deuteron runs (about 50%). The beam request is the same as for the 2010 proton run, namely 2.5×10^{13} protons delivered to the T6 target of the M2 beam line every 40.8 s. With an accelerator chain efficiency of 90% and a running time of 150 days a total of 6.1×10^{18} protons at T6 is expected. This number of protons is the basis of all the projections presented in this document.

Two detectors supported by JINR group have to be used in 2021data taking: MW1 and HCAL1 shown in Fig.14 (red squares).

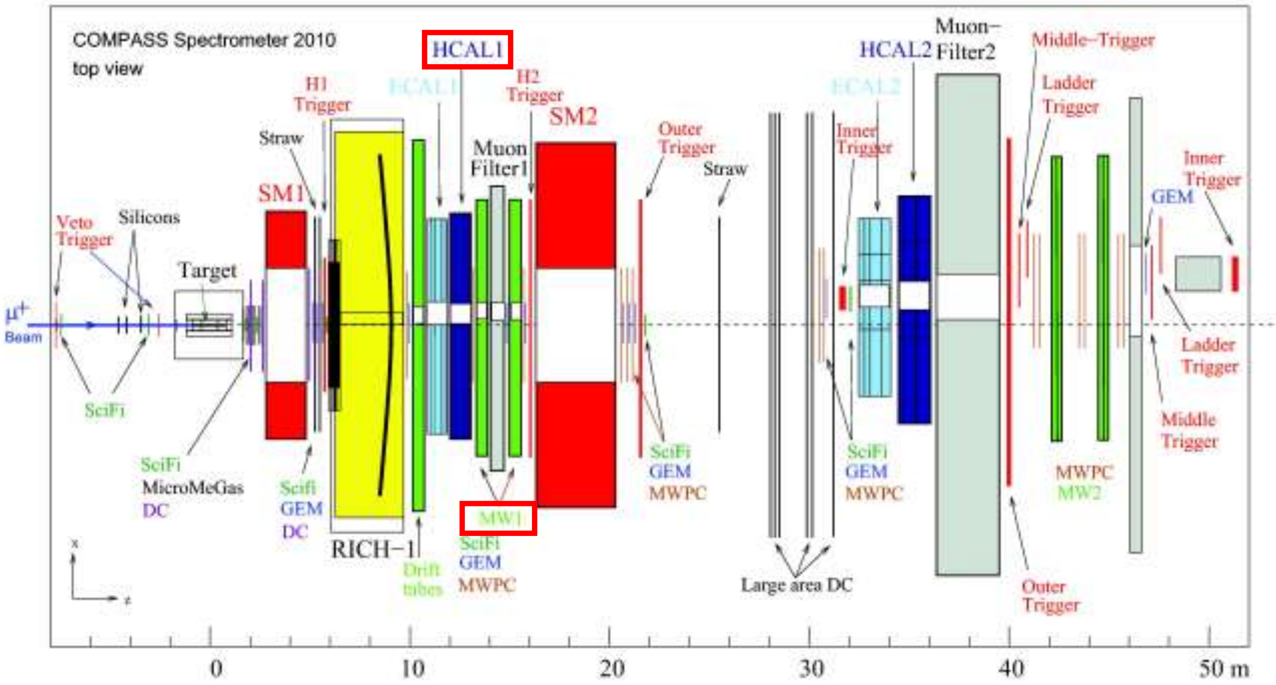

Figure 14: Schematic lay-out of the COMPASS spectrometer (top view) as it was used in 2010 and as it will be reassembled for the 2021 run.

4. JINR OBLIGATIONS AT COMPASS

According to the COMPASS-II Memorandum of understanding (MoU), JINR's responsibilities for 2021-2022 are technical support for the installation's detectors (HCAL1, ECAL0, MW1), participation in polarized target work, support for the engineering structure of the experimental hall, data collection systems, and processing and analysis of experimental data. It should be noted that SIDIS is one of the main tasks in the COMPASS-II physical program. The extension of this Memorandum until the end of 2025 was approved by the FRC and SPS committees at CERN, without obligations for detectors beyond 2021.

5. TIME LINES and FINANCIAL PROFILE.

In period of 2020-2022 COMPASS-II collaboration is going to take the experimental data with muon (2021) and continue the analysis of the experimental data taken in previous years. The plan of work for three years is presented below.

2021:

- Participation in COMPASS data taking;
- Maintenance of MW1, HCAL1 during running ;
- Development/support of MW1/HCAL1software;
- Analysis of COMPASS experimental data;

2022:

-- Completion of work with MW1, HCAL1 and ECAL0 detectors for the COMPASS-II project (utilization, export to JINR or transfer to another experiment);
- Analysis of COMPASS experimental data;

JINR's total expenses on the project (theme 1085) for the period 2017-2019 amounted to about $ 624 thousand. Scientific trips – $ 374 thousand, materials and equipment - $ 250 thousand.

CERN has allocated about $ 30,000 (NA 58, COMPASS-II) to support JINR experts at CERN. The amount of necessary funding for 2021-2022 is $ 310 thousand from the JINR budget. The main part of these expenses is required for participation of JINR physicists in data collection, for maintenance of detectors and online software systems for monitoring their operation, as well as for contributions to the Common Fund of the collaboration in accordance with the obligations under the Memorandum of understanding. Details of the spending plan are provided in forms 26 and 29 below.

In 2021-2022, 14 authors of the collaboration's publications, students, engineers and technical workers of two LSE and LSE will participate in the project. The total FTE of institute's employees for the project is 14.5, LHEP-8.2, LNP – 5.8 and LTP-0.5. The employment, status, and area of activity of each employee is shown in the following table.

No.	Name	Status	Activity	FTE	Laboratory
1	Abazov V.	tech	MW1	0,3	DLNP
2	Alexeev G.	scient	MW1	0,3	DLNP
3	Anfimov N.	scient	HCAL1,ECAL0	0,1	DLNP
4	Anosov V.	tech	Hall Engeneering	0,8	LHEP
5	Gavrishchuk O.	scient	HCAL1, ECAL0	0,2	LHEP
6	Golovanov G.	tech	MW1	0,3	DLNP
7	Gridin A.	PhD st	Data analysis	0,7	DLNP
8	Guskov A.	scient	ECAL0, Data analysis	0,3	DLNP
9	Gushterski R.	scient	Data analysis	1,0	LHEP
10	Denisenko I.	PhD st	Data analysis	0,5	DLNP
11	Efremov A.	scient	Theory	0,5	LTP
12	Jouravlev N.	scient	MW1	0,3	DLNP
13	Ivanov A.	scient	Data analysis	0,4	LHEP
14	Ivanshin Yu.	scient	Data analysis	1,0	LHEP
15	Kisselev Yu.	scient	Polarised target	1,0	LHEP
16	Kouznetsov O.	scient	Data analysis	1,0	LHEP
17	Maltsev A.	Dip.st	Data analysis	0,7	DLNP
18	Meshcheryakov G.	scient	HCAL1, ECAL0	0,5	LHEP
19	Mitrofanov Ye.	PhD st	Data analysis	0,7	DLNP
20	Nagaytsev A.	scient	Team leader,ECAL0	1,0	LHEP
21	Olchevski A.	scient	ECAL0, data analysis	0,1	DLNP
22	Peshekhonov D.	scient	Data taking	0,3	LHEP
23	Piskun A.	tech	MW1	0,3	DLNP
24	Rymbekova A.	PhD st	Data analysis	0,3	DLNP
25	Savin I.	scient	Data analysis	1,0	LHEP
26	Selyunin A.	PhD st	HCAL1, ECAL0	0,1	DLNP
27	Tokmenin V.	tech	MW1	0,3	DLNP
28	Frolov V.	scient	DAQ, ECAL0	0,5	DLNP

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Form No. 25

PROJECT ENDORSEMENT LIST

Studies of the Nucleon and Hadron Structure at CERN ATLAS COLLABORATION

Theme 02-0-1081-2009/2019

PROJECT LEADER – Alexander Nagaytsev

APPROVED BY JINR DIRECTOR	___________ SIGNATURE	___________ DATE

ENDORSED BY

JINR VICE-DIRECTOR	___________	___________
CHIEF SCIENTIFIC SECRETARY	___________	___________
CHIEF ENGINEER	___________	___________
HEAD OF SCIENCE ORGANIZATION DEPARTMENT	___________	___________
LABORATORY DIRECTOR	___________	___________
LABORATORY CHIEF ENGINEER	___________	___________
PROJECT LEADER	___________	___________

ENDORSED

RESPECTIVE PAC	___________	___________

Form No. 26

Schedule proposal and resources required for the implementation of the project "Studies of the nucleon and hadron structure at CERN"

Expenditures, resources, financing sources		Costs (k$) Resource requirements	Proposals of the Laboratory on the distribution of finances and resources	
			2021	2022
Required resourses	Operational costs	30	20	10
	Budget expenditures including foreign-currency resources.	280	170	110

PROJECT LEADER

Form No. 29

Estimated expenditures for the Project "Study of the Nucleon and Hadron Structure at CERN"

#	Expenditure items	Full cost	2021	2022
	Direct expenses for the Project			
1.	Materials and equipments	30k$	20 k$	10 k$
2.	Collab common fund	90 k$	50 k$	40 k$
3.	Travels, including outside RUSSIA inside RUSSIA	 180 k$ 10 k$	 115 k$ 5 k$	 65 k$ 5 k$
	TOTAL DIRECT EXPENSES	**310 k$**	**190 k$**	**120 k$**

PROJECT LEADER

LABORATORY DIRECTOR

LABORATORY CHIEF ENGINEER-ECONOMIST