

Questionnaire for DSS project prolongation (2022-2024).

A. Scientific merit

1. Goals of the experiment:

1a. The main goals of the DSS experiment is to obtain new and valuable information of the short range spin structure of 2-nucleon and 3-nucleon correlations in the processes with participation of polarized deuterons and protons at Nuclotron. There 2 main tools for that: i) energy scan of the deuteron analyzing powers A_y , A_{yy} and A_{xx} in deuteron-proton elastic scattering and nucleon analyzing power A_y^p in proton-deuteron elastic scattering at 150-1000 MeV/nucleon at large transverse momenta; ii) study non-mesonic deuteron breakup $p(d,pp)n$ with the detection of 2 final protons in different kinematics (complanar, space-star) at the deuteron kinetic energies of 300-500 MeV. Very important and necessary goal of the DSS project is the development of the efficient polarimetry of the deuteron and proton beams, what has great importance for spin studies at NICA at whole.

1b. The results of the project on the polarization observables in dp- and pd- elastic scattering provide unique information on the spin structure of short range correlations in the region of the transition regime from the effective baryon-meson to the fundamental quark-gluon degrees of freedom. The project extends significantly the energy range of the previous experiments performed at RIKEN, KVI, IUCF, COSY, where the process can be described within standard meson-nucleon approaches. Such study is an inevitable step in the continuation of such program at SID at NICA. The use of the specific kinematics for deuteron breakup allows to focus on the role of the relativistic effects and possible manifestation of the short range 3-nucleon forces providing new necessary information for development of modern approaches as chiral perturbation theory. Development of high-energy polarimetry within DSS project provides necessary diagnostic tools for the proton and deuteron beams inside the Nuclotron ring.

B. Achievements

2. Contributions of the JINR group:

2a. The contributions of the JINR group in hardware are the following: detectors to study deuteron breakup with the detection of 2 protons, new detectors to the study proton-proton and proton-deuteron elastic scattering, monitor detectors, internal target station with control and manipulation system, scintillation hodoscopes and straw detectors prototypes, high and

low voltage systems, data acquisition system. Apart from this JINR has a local PC cluster for data storage and analysis, simulation, as well as for three-body theoretical calculations. JINR developed software for the dp-elastic scattering data analysis, for deuteron and proton polarimetry measurements, for the simulation for pp-, dp- and pd- elastic scattering within energy range of DSS project.

2b. The responsibilities of JINR group members within the management structure of the DSS collaboration:

V.P.Ladygin- cospokeperson.

3.Publications (2019-2021):

[1] A.A.Terekhin et al., The differential cross section in deuteron-proton elastic scattering at 500, 750 and 900 MeV/nucleon, Eur.Phys.J. A55 (2019) 129.

JINR took the major part in the experiment preparation, data taking and analysis, MC simulation, paper publishing.

[2] N.B.Ladygina, On reaction mechanisms in deuteron–proton elastic scattering, Eur.Phys.J. A56 (2020) 5, 133.

JINR is fully responsible for the theoretical analysis, computer code, calculation using DSS PC cluster, and paper publishing.

[3] A.V.Tishevskiy et al., Study of the 16-Channel Scintillation Detector Prototype with Silicon Photomultiplier Readout, Phys.Atom.Nucl. 83, 12 (2020) 1691.

JINR is responsible for the scintillation prototype manufacture, testing and paper publishing.

[4] V.V.Abramov et al., Possible studies at the first stage of the NICA collider operation with polarized and unpolarized proton and deuteron beams, e-Print:2102.08477 [hep-ph], to be published in Phys.Part.Nucl. (2021).

DSS group (V.Ladygin) is responsible for the chapter 8 (pp.51-53).

Total number of papers published in 2019-2021 is about 30.

4. PhD theses:

List the PhD theses completed within the last 3 years by JINR peoples:

[1] A.A.Terekhin, Investigation of the differential cross section of the dp-elastic scattering reaction at the energies 1-2 GeV, PhD Thesis, defended in 2020, LHEP JINR, Dubna, Russia.

2 PhD theses are in preparation (A.Tishevsky and I.Volkov).

5. Talks:

Due to Covid-19 pandemy number of talks for DSS collaboration were significantly reduced, especially, in 2020.

5a. Invited plenary talks:

[1] XVIII-th Workshop on High Energy Spin Physics (DSPIN19), 2-7 September 2019, Dubna, Russian Federation.

Deuteron analyzing powers in dp -elastic scattering at large transverse momenta,

V.P.Ladygin.

5b. Parallel talks:

[1] XVIII-th Workshop on High Energy Spin Physics (DSPIN19), 2-7 September 2019, Dubna, Russian Federation,

Upgrade of the polarimeter at the Internal Target Station at the Nuclotron, A.A.Terekhin.

[2] XVIII-th Workshop on High Energy Spin Physics (DSPIN19), 2-7 September 2019, Dubna, Russian Federation,

The results of the deuteron beam polarization measurement for dp- elastic scattering reaction at 270 MeV energy,

Ya.T.Skhomenko.

[3] 24-th European Few Body Conference, 2-4 September 2019, Surrey, UK,

Study of deuteron-proton backward elastic scattering at intermediate energies,

N.Ladygina.

[4] LXIX International Conference "Nucleus-2019" , 1–5 July 2019, Dubna, Russian Federation,

Studying the Differential Cross Section of Elastic Deuteron–Proton Scattering at 1–2 GeV,

A.A.Terekhin.

[5] XXIV International Scientific Conference of Young Scientists and Specialists (AYSS-2020), 9-13 November 2020, JINR, Dubna, Russia,

Analyzing power in quasi-elastic proton-proton scattering at 500 and 650

MeV/nucleon,

I.S.Volkov.

[6] XXIV International Scientific Conference of Young Scientists and Specialists (AYSS-2020), 9-13 November 2020, JINR, Dubna, Russia, New proton polarimeter at the Nuclotron, A.A.Terekhin.

[7] XXIV International Scientific Conference of Young Scientists and Specialists (AYSS-2020), 9-13 November 2020, JINR, Dubna, Russia, Study of the 16-channel scintillation detector prototype with SiPM readout, A.V.Tishevskiy.

[8] LXX International conference "NUCLEUS – 2020. Nuclear physics and elementary particle physics. Nuclear physics technologies", 11-17 October 2020, Saint Petersburg , Russia,

Angular dependencies of the deuteron analyzing powers in dp- elastic scattering at large transverse momenta, V.P.Ladygin.

[9] Virtual workshop "Physics programme for the first stage of the NICA SPD experiment", 5-6 October 2020, JINR, Dubna, Russia, Analyzing power in dp elastic scattering at large transverse momenta, V.P.Ladygin.

C. Plans and requests

6.Plans

The plans of the JINR group for the period of time of the requested extension:

1. The physics analysis and publishing of the data obtained with unpolarized (deuteron and carbon) and polarized (deuteron and proton) beams.
2. Preparation of the measurements and data taking with nuclear beams in 2022-2024yy.
3. Preparation of the polarization measurements and data taking with polarized deuterons and protons in 2023-2024 yy.
4. Developments for the deuteron and proton polarimetry at Nuclotron and NICA. Upgrade of the internal target polarimeter.
5. R&D for scintillation detectors with SiPM readout and straw tracking detectors to enlarge the acceptance of the DSS setup.
6. Theoretical analysis of the observables in hadronic reactions with the participation of light nuclei. Performance of the numerical calculations.

7. Group size, composition and budget.

7a. List the JINR personnel involved in the project and their FTE

No	Name	Status	FTE	Task
1.	E.V. Chernykh	researcher	0.9	Electronics, data taking
2.	Yu.V.Gurchin	researcher	1.0	Detectors, data taking and analysis
3.	A.Yu.Isupov	researcher	0.7	DAQ, data taking and analysis
4.	A.N. Khrenov	engineer	0.5	Detectors, mechanics
5.	V.P.Ladygin	researcher	0.5	Management, data taking and analysis
6.	N.B.Ladygina	researcher	0.9	Data analysis and interpretation
7.	A.N.Livanov	engineer	0.1	ITS support, data taking
8.	S.G.Reznikov	researcher	0.7	Trigger, electronics, data taking
9.	A.A.Terekhin	researcher	1.0	Simulation, data taking and analysis
10.	A.V.Tishevsky	engineer	1.0	Detectors, data taking and analysis
11.	I.S.Volkov	engineer	1.0	Simulation, data taking and analysis
			8.3	

Total number of the peoples in the collaboration 39.

7b. JINR group budget is 140k\$ for the period of 2022-2024 or 100\$ for the period of 2022-2023.

Estimated expenditures for the Project Probing the Deuteron short-range Spin Structure in the (d,p) reactions using polarized deuteron beam at Nuclotron-M (DSS)

Expenditure items	Full cost	1 st year	2 nd year	3 rd year
Direct expenses for the Project				
1. Accelerator, Nuclotron-M	700	300*	200	200
2. Computers	-	-	-	-
3. Computer connection	-	-	-	-
4. Design bureau	300	100	100	100
5. Experimental Workshop	500	200	200	100
6. Materials	60	22	22	16
7. Equipment	44	16	16	12
8. Construction/repair of premises	-	-	-	-
9. Payments for agreement-based research	-	-	-	-
10. Travel allowance, including:	36	12	12	12
a) non-rouble zone countries	21	7	7	7
b) rouble zone countries	15	5	5	5
c) protocol-based				
Total direct expenses	140	50	50	40

*- partly in parasitic beam mode

PROJECT LEADER

LHEP DIRECTOR

LHEP CHIEF ENGINEER-ECONOMIST

7c. DSS collaboration is planning to use the JINR computing resources (LHEP farm) for the polarimetry data. The physics data will be treated by own PC cluster.