

# Report of the Physics Coordinator

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SPD Collaboration meeting  
Joint Institute for Nuclear Research,  
Dubna, 5-8 Nov 2024



- Convener: **Evgeny Soldatov**
  - PhD 2017, “Associated production of Z boson and photon in proton-proton collisions in the ATLAS experiment”
  - Associate Professor at MEPhI, Deputy team leader of the NRNU MEPhI group in the ATLAS experiment
- The aim of the group:
  - harmonize activities related the physics researches at the first stage of SPD
  - review of the first stage physics tasks based on the SPD detector performance

# Meetings & communications

## Meetings:

- Physics & MC – monthly, present results (3 meetings since the last CM).
- I propose to have the next P & MC meeting on Nov 20
- Physics Bi-Weekly (Tuesdays 15:00) – **communication**, presenting **intermediate** results or status, **reporting problems**, asking for help, ... (9 meetings since the last CM).
- **SPD First Stage Group Meeting (Tuesday 16:00) alternating with Physics Weekly.**

## People involved:

- Many involved people (Physics & MC – 30-45, Physics Weekly - 20-35)
- Smaller amount of actively contributing people

## SPD seminars:

- We had **one** seminar
- You can suggest topics or people for seminars

## Communications

- Email ([SPD\\_MC mail list](#), private emails)
- *Please, do not hesitate to communicate your problems via the mail list!*
- *Evaluation tests for [spd-forum.jinr.ru](#). Current aims: analysis note review, SpdRoot problems reporting.[spd-forum.jinr.ru](#)*

- When applying to conferences, please take a look at Publication Policy ([https://spd-t.jinr.ru/wp-content/uploads/2024/02/SPD\\_Publication\\_Policy.pdf](https://spd-t.jinr.ru/wp-content/uploads/2024/02/SPD_Publication_Policy.pdf))
- General talks should be approved by PubCom (spd\_pubcom@jinr.ru)
- Dedicated talks are approved by the corresponding coordinators.
- For the **physics analysis/simulation** talks
  - only results presented to our collaboration can be shown at conferences
  - please communicate the coordinator **BEFORE** submitting the abstract
  - please send the talk two weeks **BEFORE** the conference
  - please send the proceedings at least one week before the deadline
- For physics we will switch from individual talk reviews to rehearsals
- For the theoretical works, please just **notify** the PubCom.

## SCIENCE BRINGS NATIONS TOGETHER

### Small-pT J/psi production in the TMD parton model and NRQCD (by Vladimir Saleev)

Wednesday Jul 3, 2024, 3:00 PM → 4:00 PM Europe/Moscow

3:00 PM → 3:40 PM **Small-pT J/psi production in the TMD parton model and NRQCD**

🕒 40m

**Speakers:** Prof. Vladimir Saleev (Samara National Research University), Kirill Shilyaev

📎 Salee\_Shilyaev\_july\_...

## Possible Studies at the First Stage of the NICA Collider Operation with Polarized and Unpolarized Proton and Deuteron Beams

V. V. Abramov<sup>a</sup>, A. Aleshko<sup>b</sup>, V. A. Baskov<sup>c</sup>, E. Boos<sup>b</sup>, V. Bunichev<sup>b</sup>, O. D. Dalkarov<sup>c</sup>, R. El-Kholy<sup>d</sup>, A. Galoyan<sup>e</sup>, A. V. Guskov<sup>f</sup>, V. T. Kim<sup>g,h</sup>, E. Kokoulina<sup>c,i</sup>, I. A. Koop<sup>k,l,m</sup>, B. F. Kostenko<sup>m</sup>, A. D. Kovalenko<sup>c,†</sup>, V. P. Ladygin<sup>e</sup>, A. B. Larionov<sup>o,n</sup>, A. I. L'vov<sup>e</sup>, A. I. Milstein<sup>h,k</sup>, V. A. Nikitin<sup>e</sup>, N. N. Nikolaev<sup>o,z</sup>, A. S. Popov<sup>l</sup>, V. V. Polyanskiy<sup>c</sup>, J.-M. Richard<sup>q</sup>, S. G. Salmikov<sup>l</sup>, A. A. Shavrin<sup>e</sup>, P. Yu. Shatunov<sup>h,k</sup>, Yu. M. Shatunov<sup>h,k</sup>, O. V. Selyugin<sup>q</sup>, M. Strikman<sup>r</sup>, E. Tomasi-Gustafsson<sup>r</sup>, V. V. Uzhinsky<sup>m</sup>, Yu. N. Uzikov<sup>o</sup>

<sup>a</sup> NRC "Kurchatov Institute"

<sup>b</sup> Skobeltsyn Institute of Nuclear Physics

<sup>c</sup> Lebedev Physical Institute

<sup>d</sup> Astronomy Department

<sup>e</sup> Veksler and Baldin Laboratory of Nuclear Problems

<sup>f</sup> Dzhelazov Laboratory of Nuclear Problems

<sup>g</sup> Petersburg Nuclear Polytechnic University

<sup>h</sup> St. Petersburg State University

<sup>i</sup> Sukhoi State Technical University

<sup>j</sup> Budker Institute of Nuclear Physics

- Quark-instanton scattering (M.G. Ryskin talk at SPD seminar)
- Search for exotic states in central production (A. Sarantsev, SPD CM, Apr 2023)
- **Study of sum rules for TMDs** (M. Lyubovitskij, SPD CM, Oct 2023)
- **Nuclear physics tasks for light to moderate nuclei** (G Nigmatkulov, SPD CM, Oct 2023): spectra, yields, polarization phenomena, and hypernuclei production
- **Search for intrinsic strangeness** (G. Lykasov)
- Simulation if the 1-st phase of SPD is a priority now!



ELSEVIER

Progress in Particle and Nuclear Physics

Volume 119, July 2021, 103858



Review

## On the physics potential to study the

## Deuteron at

Alesio<sup>g,h</sup>, M. Deka<sup>a</sup>,  
K. O. A. Karpishkov<sup>l</sup>,  
Keh-Fei Liu<sup>r</sup> ... O.

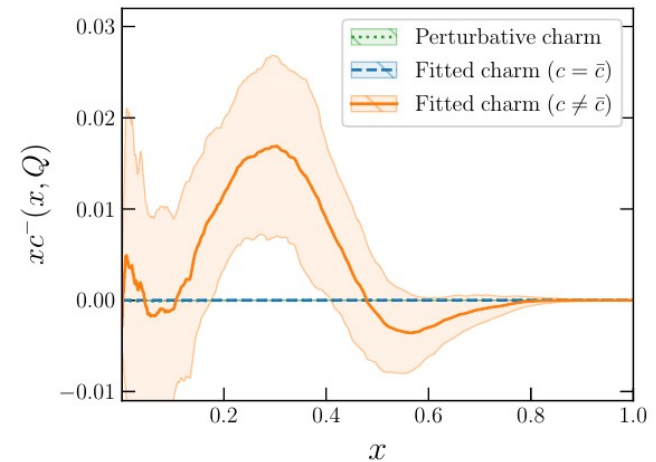
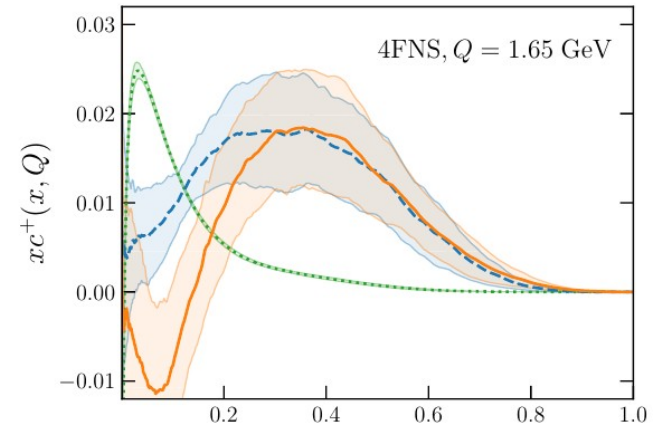
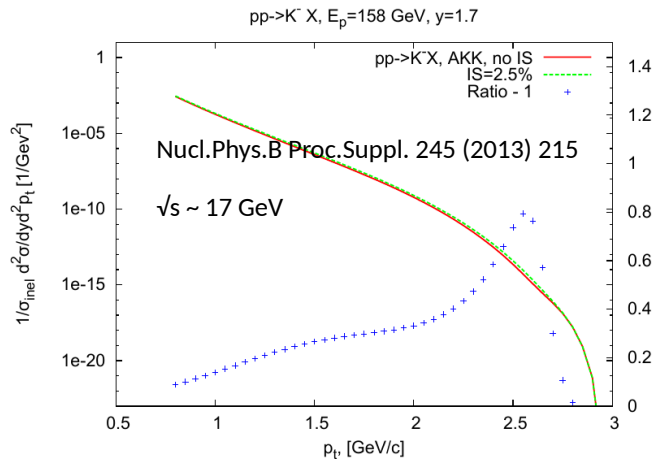
# Physics tasks: intrinsic charm/strangeness?

NNPDF Collaboration:

- Evidence of **intrinsic charm** in proton (Nature 608, 483 (2022))
- Nonzero  $x\bar{c}$  PRD 109 (2024) 9, L091501

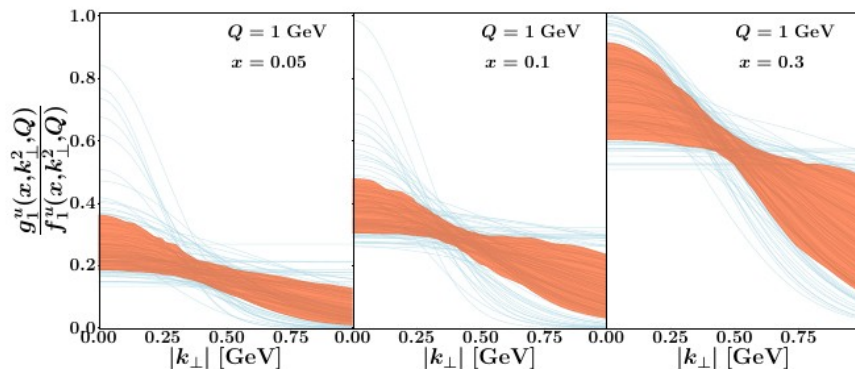
What can be the impact of our measurements with D-mesons (including asymmetries in their production)?

**Intrinsic strangeness** via inclusive kaon production at SPD? – G. Lykasov, DLNP seminar Oct 25.



NNPDF (PRD 109 (2024) 9, L091501)

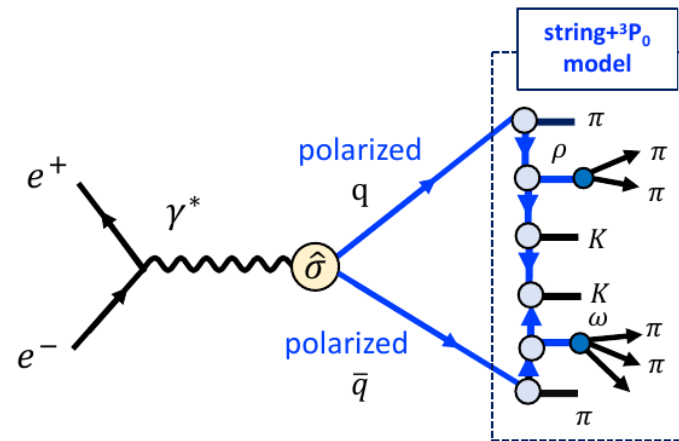
- **k<sub>T</sub>-dependence of quark helicity distributions** (from talk by A. Bacchetta) from SIDIS @HERMES
- Could SPD be sensitive to k<sub>T</sub>-dependence of gluon TMD?



MAP Collaboration, arXiv:2409.18078

Also see Yang, Liu, Sun, Zhao, Ma, arXiv: 2409.09110

- C. Pisano, “J/psi production as a probe of gluon TMD” – perturbative part of shape functions considered
- Albi Kerbizi, “Polarized hadronization in Pythia”. **StringSpinner** implemented for DIS and e<sup>+</sup>e<sup>-</sup>, **hadron collisions in plans.**



AK, Artru, PRD 109 (2024) 5, 054029  
 AK, Lönnblad, Martin, arXiv: 2407.07706



# Predictions, expected precision, and impact of our measurements

- **The SPD primary goals**

- Predictions:

- **Available:** predictions for our main probes of nucleon gluon structure in proton-proton collisions (thanks to the Samara group). **Is it possible to have  $A_N$  for  $\chi_c$ ?**
- **Not available:** asymmetries for **gluon tensor-polarized distributions** for prompt photons and  $J/\psi$ ,  $E_{xy}$  and  $A_{TT}$  from **gluon transversity** for our probes **in dd collisions?**

- Impact:

- **Estimated:** impact of inclusive  $J/\psi$  in prompt photon  $A_{LL}$  measurements for gluon helicity distribution
- **Not estimated:** impact on **unpolarized gluon PDF**, Impact of measurements with **open charm**; impact of our  $A_N$  measurements for extraction/constraining of the **GSF**.

- **The first phase of SPD**

- Lack of simulations and impact studies.

- **The simulation of 1-st phase physics is a priority!**

## The SpdRoot code is organized in two main branches:

- **master** (production code)
  - fixed “Nans” at GenFit, overlaps in ECal geometry, etc... (Andrey, Ruslan, myself). Issues with overlaps still remain.
- **development** (a candidate for production, please make merge requests and commits to this branch)
  - updates in realistic ST description, dE/dx, MVD resolution fix, added SpdRCPrimVertexFinder (Ruslan, Andrey, Vladimir, myself)
- **Almost ready:**
  - **FARICH** (see talk by Artem I.), **realistic ST hits** (see talk by Ekaterina), **VD description update** (see talk Artem V.), BBC geometry (Arkadiy)
- Once committed and tested a new container for **production** will be prepared and used. **To be done ASAP!**

Help from the software group with **automatic deployment** of these **two** branches to cvmfs singularity containers would be much appreciated!

## Ongoing/missing in SpdRoot:

- Acceptable **pattern recognition** in ST (V. Andreev, ?)
- Tracking profiling and optimization (N. Voytishin, A. Didorenko, A. Kutov)
- Realistic geometry (details, support structures, electronics, etc...) - Ruslan, Andrey M
- ECal power frame type (see talk by Andrey M.)
- ECal cluster/track matching, cluster splitting
- Cluster finding in RS (see talk by Ilia) muon identification (see talk by Ivan), calorimetry
- ZDC geometry and performance simulation
- ASHIPH option for AEG

**PVS-Studio SpdRoot code analysis** (A. Didorenko), to be reported

## Usage:

- Locally - **Docker** container
- lxui - use installation in the home folder (you may ask for up to 2 GB space) or **Singularity** image (the same as Docker, images stored in /cvmfs/spd.jinr.ru/images). See SpdRoot wiki.
- Documentation on how to build, run, and submit batch jobs via slurm at lxui is available at <https://git.jinr.ru/nica/spdroot/-/wikis/home>
- Store simulation and output files at /eos

*External collaboration members can become JINR associated personnel to get access our cluster.*

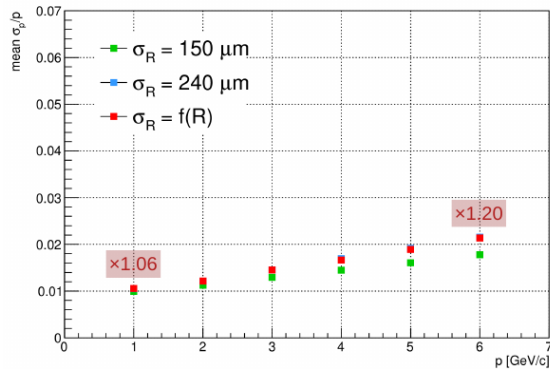
## We have the first production (many thanks to Artem!)

- Thanks to Artem, the test production using **SpdRoot 4.1.6.1** has been successfully finished in JINR and PNPI.
- There was a problem in SpdRoot and GenFit resulting in infinite loop with *Nans* printed to stdout in rare situations (jobs killed as a result of logs being above allowed limits). A patch was applied (raising exception in GenFit in this case), *the exact cause of the problem is not clear*.
- The available statistics is approximately **20M** of minbias events **@27 GeV** (as we requested), larger scale production will start soon.
- *Once FARICH, VD, and BBC changes are committed*, we may start production for the development branch of SpdRoot.
- In future, the data will be provided by **rucio** (**see Artem's talk**). Currently, you can take the list of reconstructed and par-files from my folder on eos (</eos/nica/spd/users/iden/production/test-minbias>).
- **Please, perform tests with this sample and send me the feedback!**

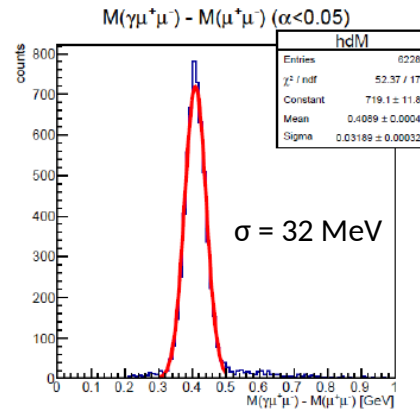
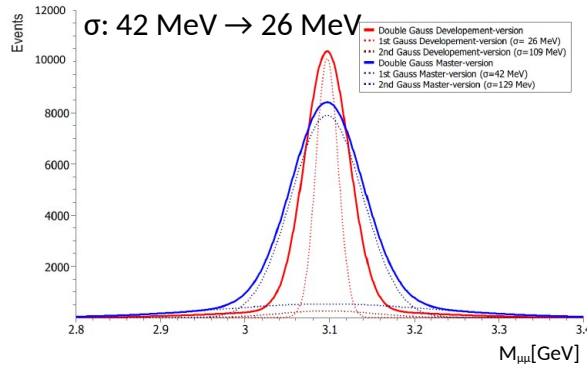
# Some results from meetings not discussed at this CM

## Mean momentum resolution $\sigma_p/p$

$\theta=90^\circ$ , MM + ST

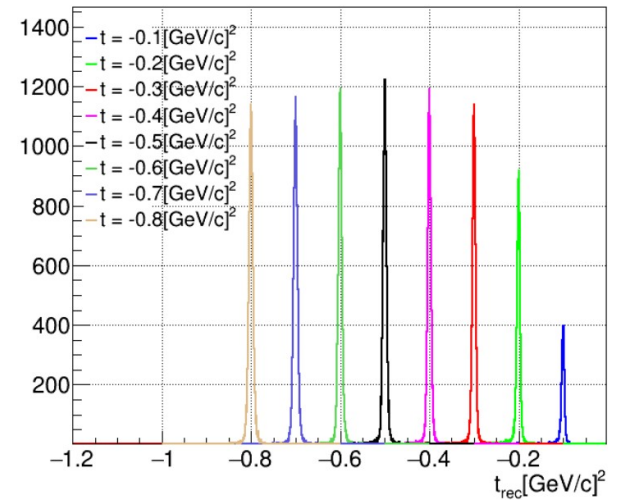


Ruslan Akhunzyanov, P&MC, 19.07.24



Zaurbek Khabaev, P&MC, 18.09.24

$\sqrt{s} = 5.0 \text{ GeV}$



Adel Terkulov, PW, 29.10.24

- **SPHINX** (*DY only*)
- **ULYSSES** (multiquark correlations) – A. Zelenov, V. Kim, work in progress
- Simulation lambda polarization effects in unpolarized pp collision (V. Kim *et al.*)
- Simulation of elastic pp scattering (A. Galoyan, V. Uzhinzky)
- **For many processes of the first SPD first phase we lack signal modeling tools.**
- **HELAC-Onia** (polarized J/psi production)
- **KatTie** (*talk by Alexey Chernyshev at P&MC, June 19*)
- Code to **import HepMC events** as a SpdRoot generator **would be useful**

# Simulation and reconstruction for analysis in SpdRoot I

Reconstruction task	Can be used?	Contact person	Note
Pattern recognition (MAPS+Straw)	±	V. Andreev	slow, not applicable for Micromegas-based ITS and ST endcaps
Pattern recognition in ST	-	V. Andreev, M. Dima	see talks at the software and physics sections
Track fitting	+	V. Andreev R. Akhunzyanov	requires optimization, update with constraint fit validation and performance tests
Primary vertex finding & fit	+	V. Andreev E. Zemlyanichkina	see talk by Vladimir validation scripts required
Secondary vertex fit	±	V. Andreev	validation scripts update required
dE/dx PID	+	R. Akhunzyanov	update for deuteron parameterization required
TOF PID	+	A. Ivanov	simplified approach
FARICH PID	-	A. Ivanov, F. Shipilov, K. Masolov,	see talk by Artem
ASHIPH	-	Vardan Tadevosyan	
Pattern recognition in ECal	+	A. Maltsev	
Clust. Energy reconstruction & position in Ecal	+	A. Maltsev	see status talk by Andrey on ECal frame
Pion/photon separation for high E	+	A. Maltsev	

# Simulation and reconstruction for analysis in SpdRoot II

Reconstruction task	Can be used?	Contact person	Note
PID in RS	-+	I. Eleckikh, myself	ongoing work, NN & Kalman-tree-like method, <a href="#">see talk by Ivan</a>
Clustering in RS	-	A. Verkheev, A.Osetrov, I. Polischuk	<a href="#">ongoing work, see talk by Ilia</a>
Energy estimation in RS	-	A. Verkheev	ongoing work
BBC	-	A. Terekhin	<a href="#">not merged to SpdRoot repository</a>
BBC MCP	-	?	
ZDC	-	Cuban group	<a href="#">See talk on Thursday</a>

## Valuable contributions can be made to

- [reconstruction validation tests](#)
- [patter recognition in ST](#)
- proper reconstruction (with combinatorial hits for “strip”-like detectors) for Its, DSSD tracker
- moving to more realistic simulation
- tracking optimization and pattern recognition,
- more realistic TOF PID (e.g. using approach for T0 of S. Yurchenko)
- track/ECal cluster association
- purging references to MC-truth
- development & application of ML approaches
- ...



# Modeling of physical processes (1-st stage)

Process	Person	Note
Elastic pp and dd scattering	A. Gridin, A. Terkulov	note update required
Problems of soft pp interactions	A. Galoyan, V. Uzhinkiy	
Single spin physics	N. Rogacheva, E. Zemlyanichkina	
Vector light and charm meson production	L. Seryogin	see talk by Leonid
Exclusive reactions with lightest nuclei and spin observables		
Multiquark correlations and exotic hadron state production	A. Galoyan, A. Zelenov, E. Zhulev	see talks by Andrey and Egor
CCR		START report by Raidel Blanco (dd→3He p)
Exclusive hard processes with deuteron		
Search for deconfinement in pp and dd central collisions		
Search for dibaryons	V. Kurbatov	Conference proceedings
Search for lightest neutral hypernuclei with strangeness -1 and -2		START report by M. Davydov
Measuring antiproton production cross-section for dark matter search		
Hadron formation effects in heavy ion collisions		START report by R. Pandey
Other studies in ion collisions		
Polarization of hyperons	D. Gubachev	
Soft photons	E. Kokoulina's group	
Bose-Einstein condensation and correlation	E. Kokoulina's group	
Quark-instanton scattering		missing note from the seminar

# Modeling of physical processes

## 2-nd stage physics

Process	Person	Note
Inclusive charmonia production	A. Karpishkov, I. Denisenko, V. Shalaev, I. Zhizhin A. Skachkova	
Inclusive $\eta c$ production		
Associate $J/\psi\gamma$	L. Alimov	
Inclusive open charm (D-mesons)	A. Datta, V. Andreev	see talk Amaresh for results on $D0$ from $D^*$ decays
Study of $\Lambda c$ signal at SPD	A. Smirnov	see talk by Artem
Search for exotic $s\bar{s}s\bar{s}$ state	L. Seryogin	
Search for glueball candidates		
Open charm from $D\mu$ and inclusive muons	A. Skachkova	
Prompt photons	A. Datta	See talk by Vitaly
Cluster particle production	D. Budkouski, A. Tumasyan	

## Online polarimetry

Process	Person	Note
Online polarimetry with BBC	A. Terekhin	result validation with production data required
Online polarimetry with $\pi0$	K. Shtejer	the 1-st note version prepared, see the Indico page
Online polarimetry with ZDC	P. Alekseev(?)	

# Modeling of physical processes

## 2-nd stage physics

Process	Person	Note
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Inclusive $\eta c$ production		
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Inclusive open charm (D-mesons)	A. Datta, V. Andreev	see talk Amaresh for results on $D0$ from $D^*$ decays
Study of $\Lambda c$ signal at SPD		
Search for exotic $ss\bar{s}\bar{s}$ state		
Search for glueball candidates		
Open charm from $D\mu$ and inclusive muons		
Prompt photons		
Cluster particle production		
<b>Process</b>		
Online polarimetry with BBC		quired
Online polarimetry with $\pi0$		ndico page
Online polarimetry with ZDC		

### A lot of opportunities to contribute:

- exclusive processes,
- multiquark correlations,
- nuclear physics tasks
- search for glueball candidates
- Intrinsic charm/strangeness
- ...

### For details see:

- Progress in Particle and Nuclear Physics 119, 103858 (2021)
- Physics of Particles and Nuclei 52, 1044 (2021)
- SPD meetings, seminars

# Agenda of Physics at CM (Thursday, 07.11.24)

## Evening session!

15:00	<b>Coffee break</b>	
	<i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	15:00 - 15:30
	<b>Triply charged pentaquark at first stage of NICA SPD</b>	<i>Egor Zhulev</i>
	<i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	15:30 - 15:50
	<b>Its description</b>	<i>Artem Vasyukov</i>
16:00	<i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	15:50 - 16:10
	<b>Exclusive <math>\phi</math> production simulation within SPDRoot</b>	<i>Leonid Seregin</i>
	<i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	16:10 - 16:30
	<b>Clustering Algorithms for SPD: A Comparative Study</b>	<i>Ilia Polishchuk</i>
	<i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	16:30 - 16:50
	<b>Activity of the Cuban group</b>	<i>Katherin Shtejer</i>
17:00	<i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	16:50 - 17:10

# Agenda of Physics at CM (Friday, 08.11.24)

10:00	<b>Production of prompt photons in the collision of longitudinally polarized proton beams</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Vitaly Yermolchuk</i> 10:00 - 10:20	
	<b>Pair production is a key tool to study TMD PDFs</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Prof. Vladimir Saleev</i> 10:20 - 10:40	
	<b>Direct photon production in the PRA: from high to low energy</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Alexey Chernyshev</i> 10:40 - 10:55	
11:00	<b>Prompt charmonium production at small pT in the soft gluon resummation approach</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Kirill Shilyaev</i> 10:55 - 11:10	
	<b>Coffee break</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	11:10 - 11:40	
	<b>Problem of emergence of nucleon mass</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Dr Vladimir Komarov</i> 11:40 - 12:10	
12:00	<b>Quark counting rules for inclusive cross section of cumulative production at central rapidities</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Vladimir Vechernin</i> 12:10 - 12:30	
	<b>Double polarized deuteron-deuteron scattering and tests of T-invariance</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Yury Uzikov</i> 12:30 - 12:50	
13:00	<b>Two particle correlations of Ks0 - mesons in proton-proton and deuteron-deuteron interactions</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Аида Галоян</i> 12:50 - 13:10	
	<b>Diquark role in production of baryons and exotic hadrons for SPD NICA energies</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Andrei Zelenov</i> 14:20 - 14:40	
	<b>MEPhI group</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Evgeny Soldatov</i> 14:40 - 15:00	
15:00	<b>SPbPU results based on State assignment</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Daria Larionova</i> 15:00 - 15:20	
	<b>Overview of the Straw Tracker simulation studies</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Ekaterina Mosolova</i> 15:20 - 15:40	
	<b>Effect of structural material in front of ECAL on the energy resolution</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Andrei Maltsev</i> 15:40 - 16:00	
16:00	<b>Coffee break</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	16:00 - 16:30	
	<b>Status of primary vertex reconstruction in SPDroot</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Vladimir Andreev</i> 16:30 - 16:50	
	<b>FARICH</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Artem Ivanov</i> 16:50 - 17:10	
17:00	<b>Muon identification in RS</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Ivan Yeletskiikh</i> 17:10 - 17:30	
	<b>Charmed baryon <math>\Lambda_c^+</math> at the SPD NICA experiment</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Artem Smirnov</i> 17:30 - 17:50	
	<b>Measuring D0 from D*+ decays at the SPD</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Amaresh Datta</i> 17:50 - 18:10	
18:00	<b>Online polarimetry with pi0</b> <i>Conference Hall, Building 215, VBLHEP, JINR, Dubna</i>	<i>Katherin Shtejer</i> 18:10 - 18:30	

- We have our **first physics group created**.
- I gave an overview the current situation with *theoretical predication, simulation software status and physics analysis status* as well as **directions where contribution is much welcome**. We have much progress in some directions.
- Please, follow the **publication policy** when applying to conferences.
- I remind you that simulation and impact estimations of the expected SPD results for **the 1-st stage** is a priority.
- For estimation of **impact of our measurements and observables in dd collisions during the second stage** help from theoreticians would be much appreciated. As well as for impact estimation of our TSSA measurements for pp collisions with our main probes of gluon structure.
- Gaudi-based (SAMPO) framework is developing, but is not as fast as we would wish to.

Thank you!