# Report of the Physics Coordinator

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SPD Collaboration meeting
Kazakh-British Technical University,
Almaty, 20-24 May 2024

Amaresh Datta

# Meetings

**Meetings:**

- Physics & MC –  monthly, present results (5 meetings since the lase CM).
- I propose to skip P & MC meetings July and August.
- Physics Weekly – **communication**, presenting **intermediate** results or status, **reporting problems**, asking for help, ... (15 meetings since the last CM).

**People involved:**

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

**SPD seminars:**

- We had 2 seminars
- You can suggest topics for seminars

**Communications**

- email (SPD_MC mail list, private emails)
- please, do not hesitate  to communicate your problems via the mail list!

# SPD seminars

**Subject** The second SPD Physics Seminar (13.12.23)

Dear colleagues,

I kindly invite you to our second SPD Physics Seminar scheduled for 13.12.2023 (Wednesday) at 11:00 MSK (GMT+3).

The seminar will be fully online via Zoom.

Speaker: Vladimur G. Baryshevsky (INP BSU, Minsk)

Title: Birefringence and nuclear precession at collisions of polarized particles (nuclei) bunches

Abstract:

Nuclear spin precession and birefringence are the macroscopic quantum effects. When polarized bunches collide their mutual refraction cause effects of nuclear spin precession and birefringence. These effects enable to measure the spin-dependent part of the elastic coherent forward scattering amplitude.

Probable manifestations of P and T odd effects could also be studied with their use. Reactions arising at particles collisions should be interpreted with the use of the above effects.

At the first stage it is proposed to initiate the first observation of the new physical phenomenon of deuteron birefringence when proton (deuteron) and deuteron bunches collide in the ring of NICA.

Before NICA launching it is proposed to start the first observation of the new physical phenomenon of the deuteron birefringence on the extracted beam used the activities, which were started in Dubna and confirmed existence of deuteron dichroism and appearance of tensor polarization for a nonpolarized high-energy deuteron beam, which passed through a nonpolarized target.

Thanks to Victor Kim for help with organizing the seminar!

**Subject** SPD seminar on Nucleon tomography in Momentum space

Dear colleagues,

I kindly invite you to our next SPD Physics Seminar devoted to the key topic of the SPD physics program. The seminar will be split in two parts scheduled for 13.03.24 and 27.03.24 at 11:00 MSK (GMT+3).

The seminar will be fully online via Zoom.

Speaker: Alexey Vladimirov

Title:
Nucleon tomography in Momentum space

Abstract:
Nucleon tomography aims to explore the internal structure of nucleons in 3D. Transverse momentum dependent distributions (TMDs) represent an important part of the nucleon tomography program, giving the image of quarks' and gluons' motions in momentum space. Accounting for the transverse motion is ultimately important for the description of low-energy and polarized processes. I review the main elements of TMD theory (including factorization theorem, perturbative computations and peculiarities of TMD evolution) and phenomenology. The presentation is split into two parts. The first is dedicated to general theory and the unpolarized sector. The second is dedicated to polarized processes, open questions, and future experiments.

- Thanks to Vladimir Saleev for help with organizing the seminar!
- What our measurements are best consistent with the TMD applicability region?
- Is it possible to use the Artemide (A. Vladimirov + collaborators) code to constrain gluon distributions from out measurements?

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

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

[a] NRC "Kurchatov Institute"—IHE[...]
[b] Skobeltsyn Institute of Nuclear [...]
[c] Lebedev Physical Insti[...]
[d] Astronomy Department, Faculty of S[...]
[e] Veksler and Baldin Laboratory of High En[...]
Dubna, Moscow[...]
[f] Dzhelepov Laboratory of Nuclear problems, Joint Institute [...]
[g] Petersburg Nuclear Physics [...]
[h] St. Petersburg Polytechnic[...]
[i] Sukhoi State Technical Univers[...]
[j] Budker Institute of Nuclear Physics[...]

Progress in Particle and Nuclear Physics
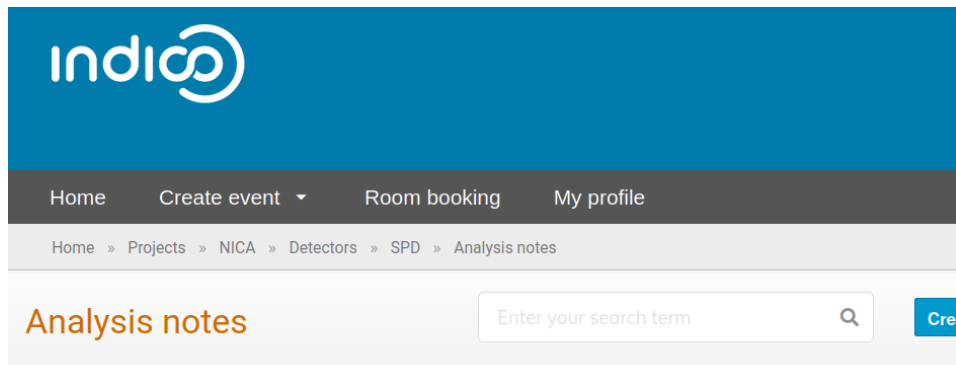Volume 119, July 2021, 103858

Review

On the physics potential to study the [...]teron at

[...]Alesio[g, h], M. Deka[a], [...], A. Karpishkov[l], [...]Keh-Fei Liu[r] ... O.

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

# Analysis notes



## Prospects of Open-Charm Asymmetry Measurements at the SPD

Amaresh Datta
JINR, DNLP
Dubna, Russia

### Contents

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- There is an Indico section for analysis notes.

- I strongly urge you to describe results of your work (not necessarily final!) in the written text.

- I hope the notes on online polarimetry and inclusive $K_s$ production will appear there soon.

# 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). See talk by A. Karphishkov on $\chi_c$ asymmetries.
    - **Not available:** asymmetries for **gluon tensor-polarized distributions** for prompt photons and J/ψ, $E_{xy}$ and $A_{TT}$ from **gluon transversity** for our probes in dd collisions?
  - Impact:
    - **Estimated:** impact of inclusive J/ψ 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** (Artemide?).
- **The first phase of SPD**
  - Lack of simulations and impact studies.
  - The simulation of 1-st phase physics becomes are priority!

# SpdRoot: status

The SpdRoot code is organized in two main branches:

- **master** (production code)
- **development** (a candidate for production)

The development branch was synchronized and should be used for any merge requests **before** they get to the master one.

For the **master** is not changed branch there are no notable changes since the last CM (essentially **4.1.6.1**). *But please do not use unicode characters in the code/script output!*

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

**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) (/cvmfs/spd.jinr.ru/images)

- 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.*

# SpdRoot: development branch

- Track fit with primary vertex and new PV reco algorithm (V. Andreev, see the at the last CM)

- ST Endcap gap corrected, bugfixes (R. Akhunzyanov)

- Micromegas inner tracker length updated to TDR value

- Additional 20% smearing added for ionization losses in straw as a rough approximation of electronics effects (R. Akhunzyanov)

- Deuteron added for dE/dx PID with preliminary parameterization (R. Akhunzyanov)

- Hit reconstruction in RS with combinatorial uncertainties (A. Gridin). Used for making ML samples for muons identification.

- Update of determination of track initial state (I. Denisenko). The procedure used before was not well-justified and inapplicable for 1 layer.

MinBias events generated with $\sigma_z = 30$ cm
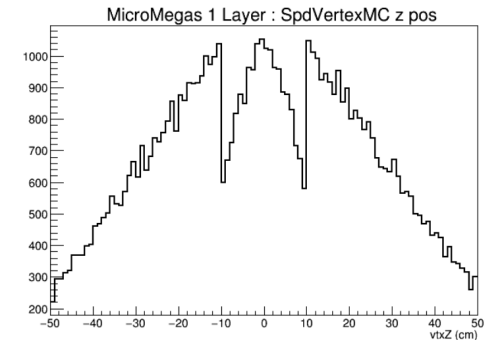


A. Datta

# Ongoing work on detector simulation and reconstruction

**SpdRoot**

- Track finding and vertex reconstruction, fixing issued for vertex fits (see talk by V. Andreev)
- Tracking profiling and optimization (N. Voytishin, A. Didorenko, A. Kutov)
- Very good progress with FARICH simulation and reconstruction (see talk A. Ivanov)
- Detector subsystem simulations with supporting structures (see talks by R. Akhunzyanov and A. Maltsev)
- New BBC geometry (A. Terekhin)
- Separation of MAPS and DSSD codes for MAPS optimization (A. Vasyukov)
- Exclusion of pathological tracks from track fitting (the suggestion by V. Lyubushkin, it can reduce time by a factor of ~3)

**Not yet related to SpdRoot**

- Muon identification in RS (talks I. Yeletskikh at our regular meetings)
- Calorimetry in RS (A. Verkheev)
- Geant4 ASHIPH simulation (see talk by V. Tadevosyan)
- Flash algorithms for track and vertex reconstruction (M. Dima, M.Dima)
- ML for FARICH by K. Massolov
- ZDC simulation (D. Gutierrez-Menendez)

# Generators

- ~~SPHINX~~ (DY only)
- **ULYSSES** (multiquark correlations) – A. Zelenov, V. Kim, work in progress
- Simulation lambda polarization effects in unpolarized pp collision (V. Kim, A. Sergeev)
- Simulation of elestic 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** (see talk by A. Chernyshev)
- 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<br>Mihai Dima | see talks at the software and physics sections |
| Track fitting | + | V. Andreev<br>R. Akhunzyanov | requires optimization, update with constraint fit validation and performance tests |
| Primary vertex finding & fit | + | V. Andreev<br>E. Zemlyanichkina | see talk by Vladimir<br>validation scripts required |
| Secondary vertex fit | ± | V. Andreev | update needed, validation scripts update required |
| dE/dx PID | + | R. Akhunzyanov | update for deuteron parameterization required |
| TOF PID | + | A. Ivanov | simplified approach |
| FARICH PID | - | A. Ivanov | work in progress (see talk by Artem) |
| ASHIPH | - | | see talk on simulation by Vardan Tadevosyan |
| Pattern recognition in ECal | + | A. Maltsev | |
| Clust. Energy reconstruction & position in Ecal | + | A. Maltsev | see status talk by Andrey |
| 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 |
| Clustering in RS | - | A. Verkheev+ | ongoing work |
| Energy estimation in in RS | - | A. Verkheev | ongoing work |
| BBC | - | A. Terekhin | not merged to SpdRoot repository |
| BBC MCP | - | ? | |
| ZDC | - | D. Gutierrez-Menendez | work resumed |

**Valuable contributions can be made to**

- reconstruction validation tests
- 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 | notes required |
| Problems of soft pp interactions | A. Galoyan | |
| Single spin physics | N. Rogacheva, E. Zemlyanichkina | see talks by Natalie and Elena |
| Vector light and charm meson production | | |
| Exclusive reactions with lightest nuclei and spin observables | | |
| Multiquark correlations and exotic hadron state production | A. Galoyan, A. Zelenov | |
| 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<br><br>Inclusive $\eta_c$ production | A. Karpishkov, I. Denisenko, V. Shalaev, I. Zhizhin<br>A. Skachkova | only gen. level results presented |
| Associate J/$\psi\gamma$ | L. Alimov | |
| Inclusive open charm (D-mesons) | A. Datta, V. Andreev | see talk Amaresh for results on D+ |
| Study of Λc signal at SPD | A. Smirnov | |
| Search for exotic ss$\overline{ss}$ state | L. Seryogin | |
| Search for glueball candidates | | |
| Open charm from Dµ and inclusive muons | A. Skachkova | |
| Prompt photons | A. Datta | |
| Cluster particle production | D. Budkouski, A. Tumasyan | |

**Online polarimetry**

| Process | Person | Note |
|---|---|---|
| Online polarimetry with BBC | A. Terekhin | see talk by Arkadiy |
| Online polarimetry with π0 | K. Shtejer | note preparation |
| Online polarimetry with ZDC | P. Alekseev, D. Gutierrez-Menendez | resumed work on ZDC simulation |

# Modeling of physical processes

**2-nd stage physics**

| Process | Person | Note |
|---|---|---|
| Inclusive charmonia production<br><br>Inclusive $\eta_c$ production | A. Karpishkov, I. Denisenko, V. Shalaev, I. Zhizhin<br>A. Skachkova | |
| Associate J/ψγ | L. Alimov | |
| Inclusive open charm (D-mesons) | A. Datta, V. Andreev | see talk Amaresh for results on D+ |
| Study of Λc signal at SPD | | |
| Search for exotic $ss\bar{s}\bar{s}$ state | | |
| Search for glueball candidates | | |
| Open charm from Dμ and inclusive muons | | s |
| Prompt photons | | |
| Cluster particle production | | |

**Online polarimetry**

| Process | | |
|---|---|---|
| Online polarimetry with BBC | | |
| Online polarimetry with π0 | | |
| Online polarimetry with ZDC | I. Alekseev, D. Gutierrez Menendez | resumed work on ZDC simulation |

**A lot of opportunities to contribute:**

- exclusive processes,
- multiquark correlations,
- nuclear physics tasks
- search for glueball candidates
- ...

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

# MC production

- Computing group is ready to start the production.
- **I see a critical need to do large scale production for open charm studies:**
  - minimum bias sample, ~1 billion events;
  - exclusive open charm (D0 → Kπ, D+ → Kππ) sample, ~10 million events;
  - both tracker configurations + PID information are required;
  - other tracker configuration may be considered.
- Similar large scale simulation can be performed for charmonia
  - exclusive J/ψ → μ+μ-, ~ 10 million;
  - tracker, ECal, RS.
- Production release is SpdRoot 4.1.6.1.Possibly we should perform simulation of a part of these samples and than move to the next SpdRoot release.
- **Please send me your needs or suggestions!**

# Agenda of Physics at CM (Friday, 24.05.24)

| 10:00 | Study of Spin Effects in the SPASCHARM Experment | Vasilii Mochalov |
| | | 10:00 - 10:20 |

| | Proposal for experiments at the SPD first stage in dd collisions | Yury Uzikov |
| | | 10:20 - 10:40 |

| | Large-pT particle production in pp-collisions at NICA energies | Andrei Zelenov |
| | | 10:40 - 10:55 |

| 11:00 | Study of multiquark fluctons in dd collisions at SPD | Vladimir Vechernin |
| | | 10:55 - 11:15 |

| | MC generator KaTie for modeling of hard processes at the NICA | Alexey Chernyshev |
| | | 11:15 - 11:30 |

| | **Coffee break** | |
| | | 11:30 - 12:00 |

| 12:00 | Double longitudinal spin asymmetries in P-wave charmonium production at the NICA | Dr Anton Karpishkov |
| | | 12:00 - 12:15 |

| | On isolated prompt photon production at the NICA | Alexandra Shipilova |
| | | 12:15 - 12:30 |

| | Small-pT J/psi production in the TMD parton model and NRQCD | Kirill Shilyaev |
| | | 12:30 - 12:50 |

| | Prompt photons with longitudinally polarised proton beams by SANC | Renat Sadykov |
| | | 12:50 - 13:10 |

| 13:00 | Test beam measurements of the straw charge and spatial resolution | Artem Chukanov |
| | | 13:10 - 13:30 |

| 14:30 | The influence of straw detector walls on momentum resolution | Ruslan Akhunzyanov |
| | | 14:30 - 14:45 |

| | ASHIPH simulation | Vardan Tadevosyan |
| | | 14:45 - 15:05 |

| 15:00 | FARICH simulation and reconstruction | Artem Ivanov |
| | | 15:05 - 15:25 |

| | Status of ECal simulation | Andrei Maltsev |
| | | 15:25 - 15:40 |

| | Status of pattern recognition and vertex fitting | Vladimir Andreev |
| | | 15:40 - 16:00 |

| 16:00 | **Coffee break** | |
| | | 16:00 - 16:30 |

| | Impact of Different Vertex Detectors on the D Meson TSSA Measurements at SPD | Amaresh Datta |
| | | 16:30 - 16:50 |

| | Charged hadron TSSA measurements at SPD | Elena Zemlyanichkina |
| 17:00 | | 16:50 - 17:05 |

| | Analysis of K_{S} production | Natalia Rogacheva |
| | | 17:05 - 17:20 |

| | Simulation of the pp-scattering in BBC in the magnetic field | Arkadiy Terekhin |
| | | 17:20 - 17:40 |

| | Fragmentation functions | Олег Самойлов |
| | | 17:40 - 17:55 |

# Summary

- I gave an overview the current situation with theoretical predication, simulation software status and physics analysis status as well as **points where contribution is much welcome**. We have much progress in some directions.

- Simulation and impact estimation of the expected SPD results for the 1-st phase becomes a priority.

- At our stage the preparation and circulation of analysis notes would be very beneficial for the whole collaboration.

- For estimation of impact of our measurements and observables in dd collisions 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 framework is developing, but is not as fast as we might wish to (help and volunteers would be much appreciated!).

Thank you!