# Report of the Physics Coordinator

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SPD Collaboration meeting
24-27 April 2023

# Organizational issues

**Meetings:**

- Physics & MC – monthly, present results
- The next Physics and MC meeting: 24.05.2023
- Physics (Bi-)Weekly – **communication**, presenting intermediate results or status, reporting problems, asking for help, …

**People involved:**

- Many involved people (Physics & MC – 30-40, Physics Weekly - 20-30)
- Smaller amount of actively contributing people
- A lot of **new groups show** interest for work in various fields (simulation, reconstruction, analysis, software development)

**SPD seminars:**

- We had one seminar (invited M. G. Ryskin from PNPI).
- We will continue in future (you may suggest topics or people)

**Communications**

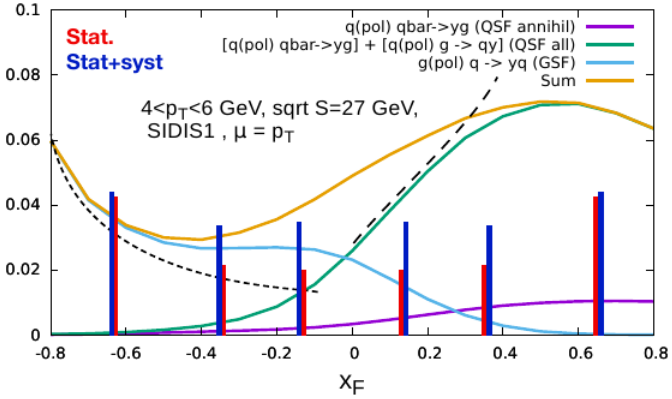
- email (SPD_MC mail list, private emails)
- please, do not hesitate to communicate your problems via the mail list!

Theoretical predictions, precision of our measurements and their impact

# Predictions & expected precision of our measurements

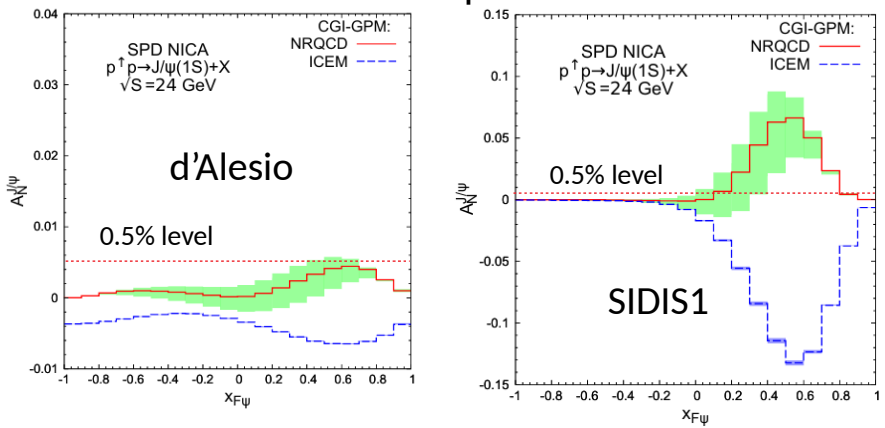
**For our main probes of proton gluon structure we have**

- predictions (thanks to the **Samara group**, prediction for $A_N$ are shown)
- projected statistical uncertainties (in case of D-mesons we need an update)

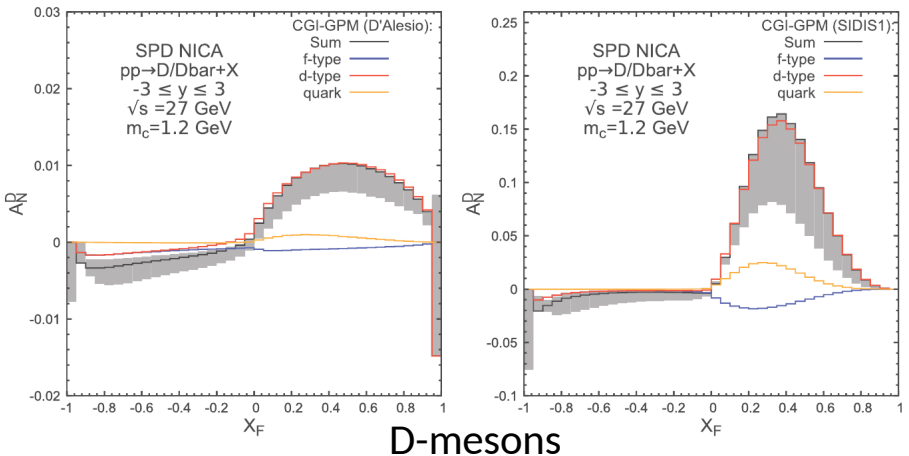



prompt photons

J/ψ




D-mesons



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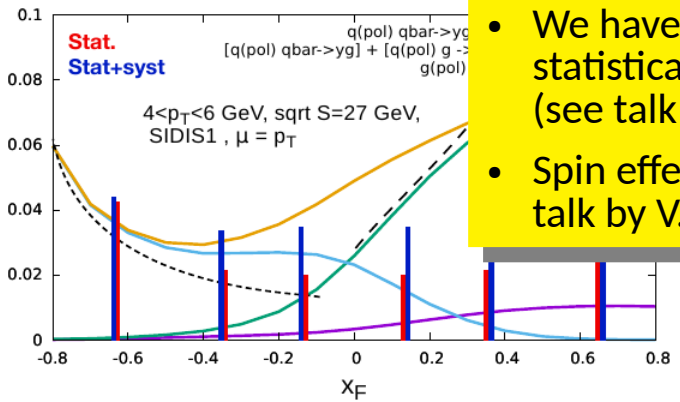
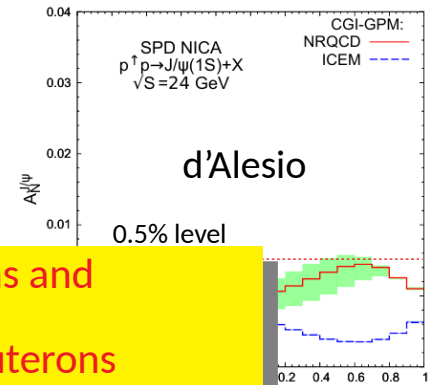
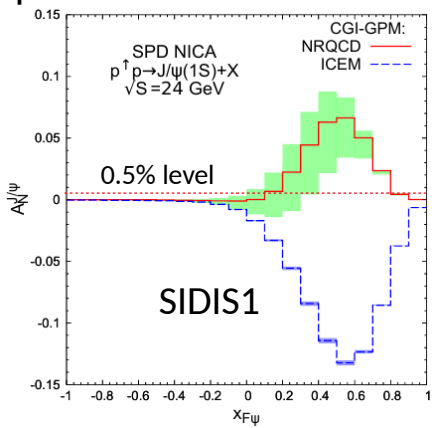


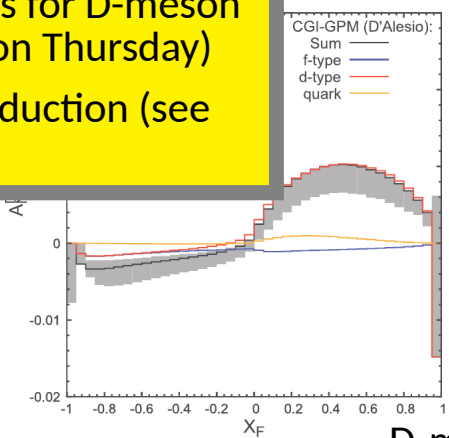

prompt photons

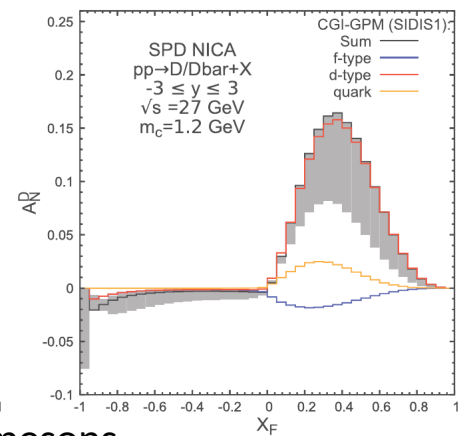
- We have no predictions and estimated precision of measurements for deuterons
- We have an update for estimated statistical uncertainties for D-meson (see talk by Amaresh on Thursday)
- Spin effects in J/ψ production (see talk by V.Saleev)

J/ψ



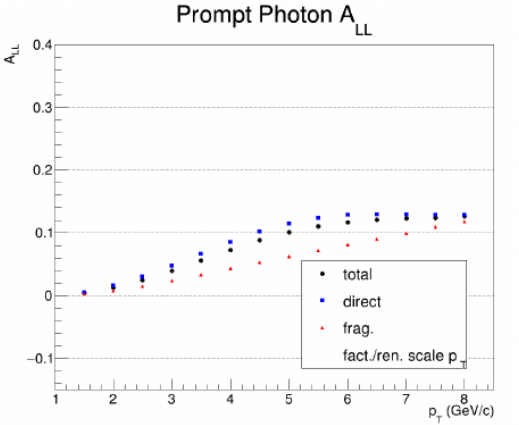



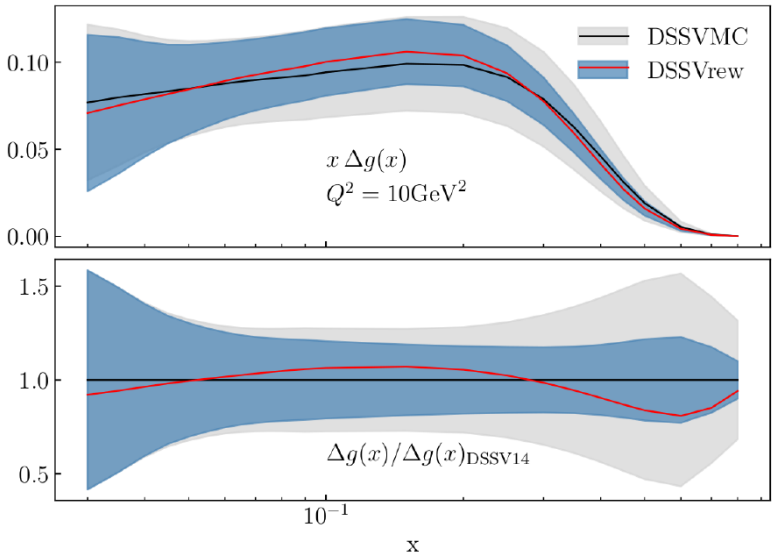

D-mesons

# Impact

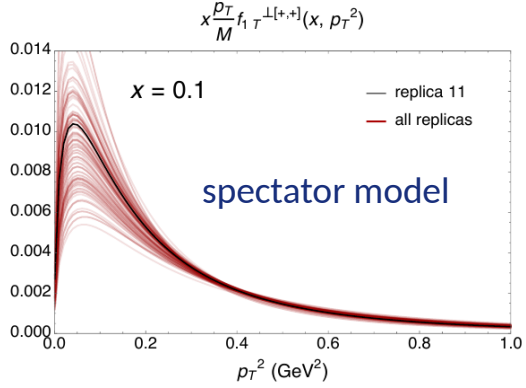



## The impact of our measurements

- is estimated for our prompt photon $A_{LL}$ measurements
- can be expected soon for the J/ψ $A_{LL}$ measurements



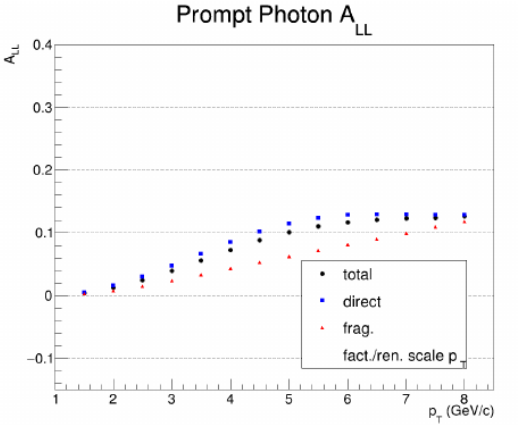

- Impact on unpolarized gluon PDF
- Is it possible to estimate impact of out $A_N$ measurements for extraction/constraining of the GSF?
- Can the following results be used for this purpose?

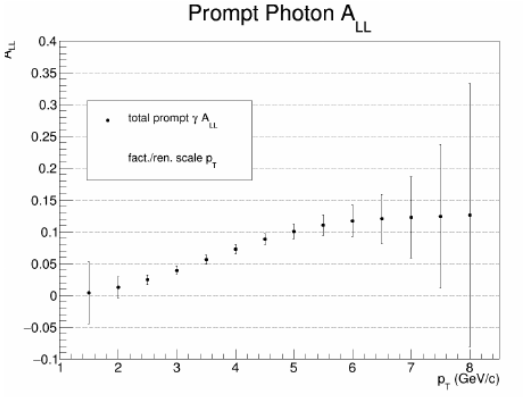



$p_T$-dependence for f-type Sivers TMD in the **spectator model**, Bacchetta, Celiberto, Radici, 2022

Courtesy: Sassot, Borsa, 2021, from A. Datta at NUCLEUS 2021

# Impact

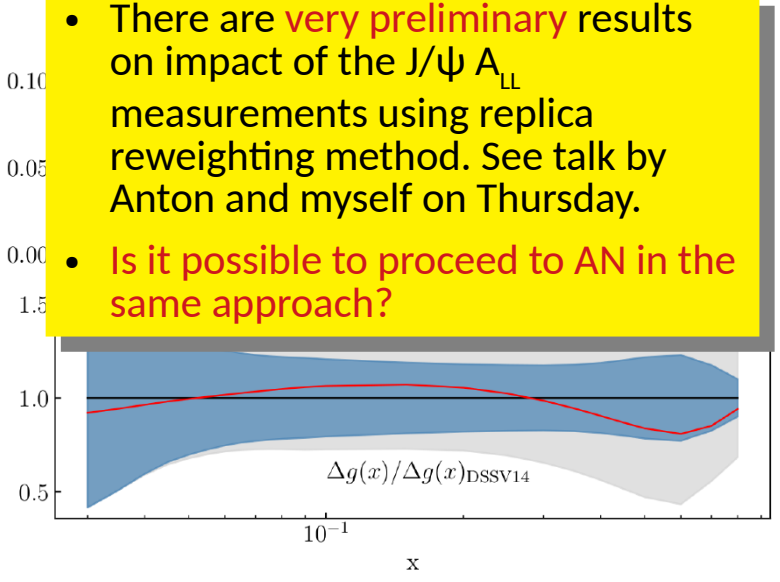



## The impact of our measurements

- is estimated for our prompt photon $A_{LL}$ measurements
- can be expected soon for the J/ψ $A_{LL}$ measurements

- There are very preliminary results on impact of the J/ψ $A_{LL}$ measurements using replica reweighting method. See talk by Anton and myself on Thursday.
- Is it possible to proceed to AN in the same approach?

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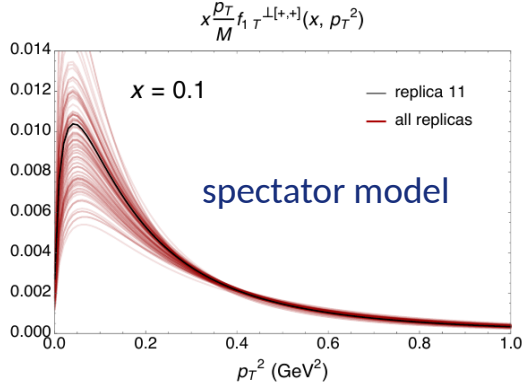


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Simulation, reconstruction, and analysis

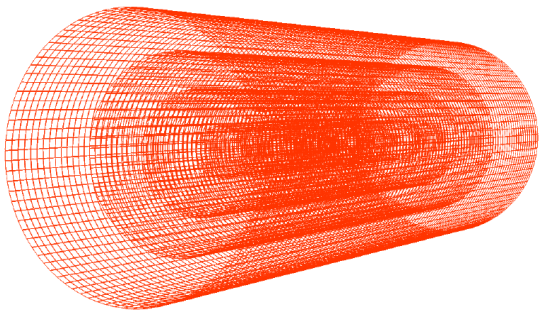
# Work with generators

- Generator validation and improved generator for elastic pp-scattering (see talk on Thursday) – A. Galoyan, V. Uzhinsky
- ULYSSES (multiquark correlations) – A. Zelenov, V. Kim
- Zh. Kurmanaliev and V. Aleksakhin work on obtaining results for polarized collisions with SPHINX
- A. Anufriev implemented $\eta_c$ production in Pythia8 (see talk at Physics Weekly 11.04.2023)

# Geometry description in SpdRoot

**Geometry**

- All main detector subsystems are described, but
  - MAPS vertex detector is described differently from TDR (see my talk at P & MC 9.11.2023). Its optimization and finding optimal configuration is extremely important task not yet assigned to anybody.
  - For AEG only basic volumes are included. Two configuration should be simulated in future: threshold and RICH.
  - BBC MCP are not descried.
  - ZDC is modeled separately.
- Geometry updates
  - BBC geometry update and usage (see talk by Zhanibek 22.03.2023) examples not yet merged to the master brunch.
  - ECal geometry/fixes made by Andrey
- The detector size will be increased, and update of subsystems is required as well as new magnetic field map.



# Simulation in SpdRoot

**SpdRoot is mostly “fast simulation” tool**

- except ECal
- ongoing work by Gatchina group (E. Kuznetsova *et al*) towards realistic straw simulation (see talk by S. Bulanova and poster by A. Mukhamejanova)

# Reconstruction in SpdRoot

| Reconstruction task | Can be used for analysis? | Contact person | Note |
|---|---|---|---|
| Pattern recognition (MAPS+Straw) | ± | V. Andreev* | slow, may not be applicable for Micromegas-based central tracker, validation scripts missing in SpdRoot |
| Pattern recognition from ST to VD or CT | | | TBA |
| Track fitting | + | V. Andreev* | requires optimization, issues for low-momentum tracks, many people faced issues with tracking efficiency for low-momentum tracks – see talk by Ruslan on Thursday), **standard selection criteria are required** |
| Primary vertex finding & fit | + | V. Andreev* | validation scripts required |
| Secondary vertex fit | ± | V. Andreev* | validation scripts required, fixes by Elena for decay pos. |
| dE/dx PID | + | R. Akhunzyanov | dE/dx for deuteron is close to be released |
| TOF PID | + | A. Ivanov | simplified approach, now deuteron is added (see talk by Artem) |
| Pattern recognition in ECal | + | A. Maltsev | no barrel-endcap cluster matching |
| Energy reconstruction in Ecal | + | A. Maltsev | |
| pion/photon separation for high E | + | A. Maltsev | now in SpdRoot |
| PID in RS | -+ | V. Zel, I. Eleckih, me | ongoing work, Kalman-like method - slow |
| Energy estimation in  in RS | | | TBA |

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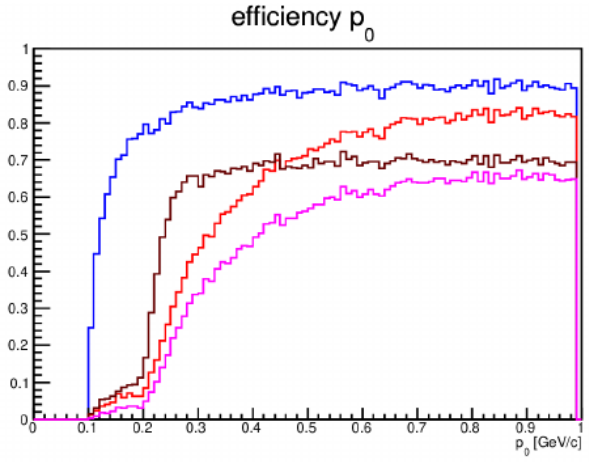
| PID in RS | -+ | V. Zel, I. Eleckih, me | ongoing work, Kalman-like method - slow |
| Energy estimation in in RS | | | TBA |

**Valuable contributions can be made to**

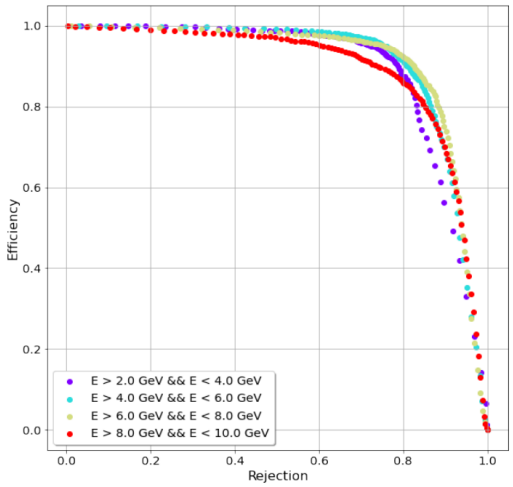
- proper reconstruction (with combinatorial hits for “strip”-like detectors) for MCT, DSSD, RS
- moving to more realistic simulation
- new pattern recognition algorithms (ST → MCT),
- tracking optimization,
- validation primary and secondary vertex fitting,
- improved TOF PID (e.g. using approach for T0 of S. Yurchenko)
- matching ECal clusters in the barrel and endcaps
- reconstruction for aerogel counters and RICH,
- PID and particle energy estimation in RS,
- …

# Reconstruction in SpdRoot

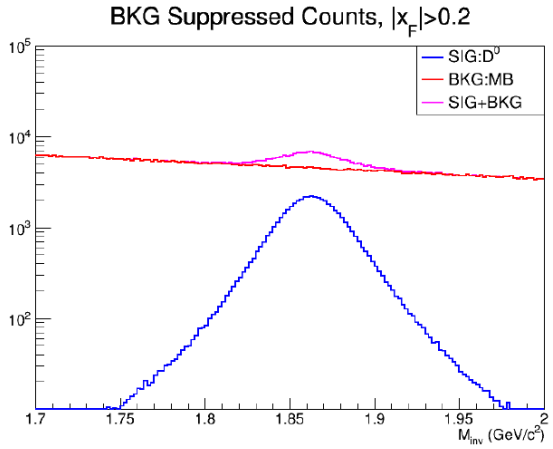



Track fitting efficiency for pions under different cuts, R. Akhunzyanov, Weekly, 04.04.23

Efficiency/rejection for different energies




Photon/pi0 separation, A. Maltsev, P &MC, 25.01.23




$D^0 \rightarrow K\pi$, A. Datta, Physics & MC 22.03.23

- SpdRoot can be used to study most the most physics processes at SPD
- Many reconstruction algorithms in SpdRoot are MC-truth dependent

# Modeling of physical processes (1-st stage)

| Process | Person | Note |
|---|---|---|
| Elastic pp and dd scattering | A. Gridin, A. Terkulov | feasibility of small-angle measurements |
| Problems of soft pp interactions | R. Akhunzyanov, A. Ivanov, E. Zemlyanichkina | acceptances, efficiencies for $\pi^0$, $K_s$, charged particles |
| Single spin physics | | |
| Vector light and charm meson production | | effect of absorber instead of ECal at 1-st stage |
| 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 | |
| Search for lightest neutral hypernuclei with strangeness -1 and -2 | M. Davydov* | START report |
| Measuring antiproton production cross-section for dark matter search | | |
| Hadron formation effects in heavy ion collisions | R. Pandey* | START report |
| Polarization of hyperons | | |
| Soft photons | E. Kokoulina's group | |
| Bose-Einstein condensation and correlation | E. Kokoulina's group | |
| Quark-instanton scattering | | recent seminar (missing minutes) |

# 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. Anufriev | impact of SPD ALL measurements for J/ψ<br><br>ηc production implemented in Pythia8 |
| Associate J/ψγ | L. Alimov | The first generator-level studies |
| Inclusive open charm | A. Datta, V. Andreev | Extensive cross-checks, estimation of signal to background ratio and statistical uncertainties |
| Open charm from Dμ and inclusive muons | A. Skachkova | ongoing generator-level studies |
| Prompt photons | A. Guskov, A. Datta | no updates since CDR and impact of ALL |
| Cluster particle production | D. Budkouski, A. Tumasyan | the first results |

## Online polarimetry

| Process | Person | Note |
|---|---|---|
| Online polarimetry with BBC | Zh. Kurmanaliev, A. Terekhin | Geometry optimization, elastic pp and dd processes, impact of the solenoidal magnetic field |
| Online polarimetry with π0 | K. Shtejer | update |
| Online polarimetry with ZDC | N. Zhigareva, P. Alekseev | |

# Modeling of physical processes

## 2-nd stage physics

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| Inclusive open charm | | nation of signal to cal uncertainties |
| Open charm from Dμ and inclusive muons | | ies |
| Prompt photons | | pact of ALL |
| Cluster particle production | | |

**A lot of opportunities to contribute:**

- physics with main probes of gluon structure,
- exclusive processes,
- multiquark correlations,
- …

For details see:

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

## Online polarimetry

| Process | | |
|---|---|---|
| Online polarimetry with BBC | | tic pp and dd processes, gnetic field |
| Online polarimetry with π0 | | |
| Online polarimetry with ZDC | N. Zhigareva, P. Alekseev | |

# Working with SpdRoot

- **I strongly recommend using the docker image for installation.**
- Many scripts with **outdated code** and **many examples missing** (e.g. on using PID) – difficult to start working with. It should be a priority to fix them. There are build issues.
- Generally, it's hardly possible to use it without personal communication (please, don't hesitate to ask questions!). A possibility of organizing a dedicated workshop is considered.
- SpdRoot is very resource consuming for both CPU and storage. Possibility to create accounts for SPD members from other universities would much facilitate our work.
- A lot of issues with batch on LIT and the VLHEP clusters.

# MC production

- **As for now, I see a critical need to do large scale production for open charm studies:**
  - exclusive open charm ($D^0 \to K\pi$, $D^+ \to K\pi\pi$) sample, ~10 million events;
  - minimum bias sample, ~1 billion events;
  - both tracker configurations + PID information are required;
  - other tracker configuration may be considered.
- Similar large scale simulation can be performed for charmonia
  - exclusive $J/\psi \to \mu^+\mu^-$, ~ 10 million;
  - minimum bias, ~ 1 billion;
  - tracker, ECal, RS.
- **Please, communicate to me you suggestions!**

# Agenda of Physics & MC day at CM

| | | | |
|---|---|---|---|
| 10:00 | **Production of exotic states in central production** | *Andrey Sarantsev* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 10:00 - 10:30 | |
| | **J/psi production and spin effects in collisions of unpolarized protons** | *Prof. Vladimir Saleev* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 10:30 - 10:50 | |
| | **Impact of SPD J/psi ALL measurements** | *Anton Karpishkov* | |
| 11:00 | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 10:50 - 11:10 | |
| | **Coffee break** | | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 11:10 - 11:40 | |
| | **Straw signal parametrization based on Garfield++ simulation studies** | *Sofia Bulanova* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 11:40 - 12:00 | |
| 12:00 | **Track fitting performance for soft particles in SpdRoot** | *Ruslan Akhunzyanov* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 12:00 - 12:20 | |
| | **KS reconstruction** | *Natalia Rogacheva* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 12:20 - 12:40 | |
| | **PID status** | *Artem Ivanov* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 12:40 - 13:00 | |
| | **Status of reconstruction in ECal** | *Andrei Maltsev* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 14:20 - 14:40 | |
| | **Generator for pp elastic scattering** | *Aida Galoyan* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 14:40 - 15:00 | |
| 15:00 | **Small-angle elastic pp scattering** | *Adel Terkulov* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 15:00 - 15:20 | |
| | **Clustet particle production at SPD** | *Dzmitry Budkouski* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 15:20 - 15:40 | |
| 16:00 | **Coffee break** | | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 16:00 - 16:30 | |
| | **Measuring D0 at SPD Via Hadronic Channel** | *Amaresh Datta* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 16:30 - 16:50 | |
| | **J/psi gamma simulation at SPD** | *Lev Alimov* | |
| 17:00 | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 16:50 - 17:10 | |
| | **Inclusive pi0 for local polarimetry in SPD** | *Katherin Shtejer* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 17:10 - 17:30 | |
| | **First results of the pp- and dd-scattering simulation for BBC SPD** | *Arkadiy Terekhin* | |
| | *Conference Hall, Building 215, VBLHEP, JINR, Dubna* | 17:30 - 17:50 | |

# Summary

- We have much interest for participation in physics and MC simulations. I tried to make an overview of the **current situation** and **suggested tasks**.
- Our simulation software is capable of simulating most of the suggested physical processes. Many processes, especially from the suggested for the first stage has not been investigated yet.
- Work on improving simulation, reconstruction, their validation, maintaining geometry and analysis tools in SpdRoot is a basement for future MC studies.
- Gaudi-based framework is developing much slower than I expected (help would be appreciated). SpdRoot will likely remain our main simulation software at least for anther year. It has been a number of improvements in SpdRoot.
- Except for $A_{LL}$, the impact of future SPD measurements on our understanding of polarized and unpolarized proton and deuteron gluon structure has not been estimated yet.

Thank you!