Report of the SPD Detector Advisory Committee

IVAN LOGASHENKO (BINP) *on behalf of SPD DAC*

SPD DAC members

Prof. Eduard Kistenev

Brookhaven National Laboratory (retired)
PHENIX/sPHENIX

Prof. Heng Yuekun

IHEP CAS

BESIII, Daya Bay, JUNO

Prof. Huang Xingtao

Shandong University

BESIII, STCF, Daya Bay, JUNO

Prof. Ivan Logashenko (chair)

BINP, Novosibirsk

CMD-2, CMD-3 (BINP),
Muon G-2 (BNL, FNAL), SCTF

SPD DAC mandate

The main purpose of the DAC is to ensure that a state-of-the-art detector is designed, constructed and installed in a timely manner to address the physics mission of the SPD.

The SPD CDR was approved in January 2022, and the SPD team was given green light to proceed with the preparations for the TDR. There has been some delay in the work of the SPD team incurred by the current geopolitical situation, and consequently there is no firm deadline for the submission of the TDR. However, it is expected that the TDR should be submitted within 1-1.5 years.

The DAC is expected to provide advice and specific recommendations on all the current and subsequent stages of the SPD realization including:

-the Technical Design Report: evaluate the specific detector choices, detector simulations and performance as well as the schedule, manpower, management organization and cost of the project.

-the construction, test, installation and commissioning of all SPD sub-systems.

In each one of these stages, the DAC should monitor and evaluate the execution:

-verifying the technical progress with respect to the project timeline

-tracking the milestones

-ensuring that the resources available are adequate for the realization of the project

The DAC should make comments and recommendations on these items as needed.

The DAC should meet regularly with the SPD team at the discretion of the Chairperson. Two meetings per year seems to be a reasonable frequency, but the Chairperson or the SPD team could call for additional meetings if needed. Alexander Cheplakov, Scientific Secretary of the PAC and the DAC, shall help in the coordination and organization of these meetings.

Reports from the DAC meetings should be made available to the PAC-PP Chairperson and to the JINR management. In addition to that, the PAC-PP Chairperson might invite the DAC Chairperson to report to the PAC-PP at one of its regular meetings.

- the Technical Design Report: evaluate the specific detector choices, detector simulations and performance as well as the schedule, manpower, management organization and cost of the project.

SPD collaboration

Joint Institute for Nuclear Research (JINR)
Dubna, Russia — A. Guskov, V. Ladygin

Budker Institute of Nuclear Physics of the Russian Academy of Sciences
Novosibirsk, Russia — A. Barnyakov

Tomsk State University
Tomsk, Russia — V. Lyubovitskij

Samara National Research University
Samara, Russia — V. Saleev

Peter the Great St. Petersburg Polytechnic University (SPbPU)
St. Petersburg, Russia — Ya. Berdnikov

University of Belgrade
Belgrade, Serbia — D. Maletic

Institute of Nuclear Physics
Almaty, Kazakhstan — S. Sakhiyev

Institute for Nuclear Research RAS
Troitsk, Russia — E. Usenko

National Research Nuclear University MEPhI
Moscow, Russia — G. Nigmatkulov

Institute for Nuclear Problems of BSU
Minsk, Belarus — A. Lobko

Skobeltsyn Institute of Nuclear Physics of the Moscow State University
Moscow, Russia — A. Berezhnoy

Petersburg Nuclear Physics Institute (NRC KI – PNPI)
Gatchina, Russia — V. Kim

National Science Laboratory
Yerevan, Armenia — N. Ivanov

Lebedev Physical Institute of the Russian Academy of Sciences
Moscow, Russia — V. Andreev

Belgorod National Research University
Belgorod, Russia — A. Kubankin

St. Petersburg State University
St. Petersburg, Russia — V. Vechernin

National Research Center Kurchatov Institute
Moscow, Russia — I. Alexeev

Cairo University
Cairo, Egypt — R. El-Kholy

Tsinghua University
Beijing, China — Y. Wang

CTEPP, UNAB
Santiago, Chile — S. Kuleshov

China Institute of Atomic Energy
Beijing, China — X. Li

Higher Institute of Technologies and Applied Sciences (InSTEC)
Havana, Cuba — F. Guzman

Higher School of Econimics
Moscow, Russia — F. Ratnikov

Institute of applied physics of the NAS of Belarus
Minsk, Belarus — R. Shulyakovsky

SAPHIR
Santiago, Chile — S. Kuleshov

Gomel State Technical University
Gomel, Belarus — V. Andreev

iThemba LABS
Somerset West, South Africa — N. Stodart

The collaboration is active and growing.

SPD collaboration - responsibilities

Activities	Participating Institutions
Vertex detector	Charles Univ., Czech Technical Univ., University of Turin and INFN Turin section, JINR, NPI MSU, IHEP, SPbSU
Straw tracker	INP SBU, JINR, PNPI, China Institute of Atomic Energy, INP NAS Kazakhstan
TOF	Tsinghua Univ, IHEP, LPI
Aerogel	Alikhanyan National Laboratory, BINP
ECAL	Alikhanyan National Laboratory, Tsinghua Univ., Warsaw Univ. of Technology, JINR, Kharkiv National University, ISMA, China Institute of Atomic Energy
Range system	JINR, NPI MSU
BBC	Chile, JINR, ITEP, Belgorod State Univ., SPbSU, MEPhI
ZDC	JINR, ITEP, Belgorod State Univ.
Micromegas central tracker	JINR, China Institute of Atomic Energy
Magnetic system	JINR, BINP

Activities	Participating Institutions
Beam line / beam pipe	JINR
Infrastructure of experimental zone	JINR
Safety	JINR
DAQ and FFE	Chile, JINR, University of Turin and INFN Turin section, NPI MSU, INR, SPbPU, Belgorod State Univ.
Computing & software	Cairo Univ., JINR, LPI, PNPI, Samara Univ., iThemba LABS, Belgrade Univ., Kharkiv National University, ISMA, Gomel Univ., SPbSU, MEPhI, HSE, BINP
Slow control and online monitoring	JINR, NPI MSU, Belgorod State Univ., iThemba LABS
Monte Carlo simulation	Alikhanyan National Laboratory, InSTEC, Cairo Univ., JINR, LPI, PNPI, NPI MSU, ITEP, Samara Univ., SPbPU, Tomsk State Univ., Belgrade Univ., Gomel Univ., SPbSU, MEPhI

SPD DAC meetings

- DAC meeting, Jan.25, 2024

Start-up meeting

- DAC meeting, Feb.6, 2024

Discussion with spokespersons

- DAC meeting, Feb.27, 2024

Presentations by SPD collaboration

- List of questions, May 7, 2024
- DAC meeting, June 4, 2024

Discussion of responses

At the CDR review is was found that the proposed detector will meet the physics goals of experiment. We haven't questioned/reviewed the overall detector design.

We reviewed only the detector-related issues and assumed that NICA accelerator complex will be able to deliver beams as proposed in TDR.

Documents provided: CDR, TDR, presentations

Q1,Q2: Justification of phase 1

Q1: Show results from the simulations which demonstrate that performance of stage 1 detector is enough to reach the physics goals for stage 1 experiments.

The main analysis and simulation efforts of the collaboration have been aimed at justifying the feasibility of achieving the primary goals of the SPD experiment with the final detector configuration. The physics of the first stage has been studied, but it has received less attention. Nevertheless a number of studies for particular measurements at phase 1 were performed to demonstrate that performance of phase 1 detector is suitable. … Now the focus of collaboration efforts is shifting to the physics of the first phase.

Q2: Is stage 1 physics-motivated or technical-motivated?

Due to the considerable uncertainty of the conditions of the first stage of the experiment (type of beams, energy, luminosity, polarization), we were primarily guided by technical considerations and cost considerations also.

Q3,Q4: Design of stage 1

Q3: Provide the realistic time schedule for the design/construction/installation of stage 1 subsystems.

A preliminary version of the work plan for the major subsystems of Phase I is attached as a supplementary document.

Q4: The design of stage 1 subsystems seems to be incomplete (electronics, production plan, assembly design). How these open questions are planed to the fixed within tight stage 1 schedule.

We have complete certainty about the analog and digital electronics for the RS. Several development cycles have already been completed. There is an understanding of the required electronics for the Micromegas-based center tracker and a sufficient number of chips required. However, additional R&D is required. For the Straw tracker, we with have done R&D with several types of electronics. However, we do not currently have full assurance that it will be available for use. In parallel, the Institute of Nuclear Problems of BSU is developing the electronics with required parameters.

Our contractors are actively working on the complete assembly scheme of the first stage subsystems. The work should be completed by the middle of next year.

Q5: Cylindrical Micromegas

Q5: Magnet, range system and straw tracker are based on well-established detector technologies and JINR has experience with them. The inner tracker for stage 1 is based on the cylindrical Micro-Megas detector which is not common and, to the best of our knowledge, is not produced in JINR. The development of MM inner tracker requires additional R&D and there risks of not constructing the subsystem in time. Please, comment how these risks are planned to be mitigated..

The JINR group has both experience in assembling Micromgas detectors for the ATLAS experiment and experience in building bulk-Micromegas detectors at its own production site. At present, prototypes of the detector for SPD with the required radius of curvature have already been built and are being tested. We also have a sufficient amount of VMM3 chips in stock for FFE.

Q6: Test beams

Q6: Comment on the availability of the test beams for R&D and commissioning of the stage 1 subsystems.

As a part of the SPD project, we develop and equip a test area on the extracted beams of the Nuclotron (SPD Test Zone) where hadrons with low (up to 1.5 GeV/c) and high (up to 7 GeV/c) momenta will be available. The area has spectrometric magnets, a track system is being set up, and a Cherenkov counter is ready to be installed. An electron machine LINAC-200 should be in operation at DLNP JINR at the end of the year that provides electron beam up to 200 MeV. An upgrade to 800 MeV is possible in the coming years. For testing prototypes we plan to use also machines: U-70 in Protvino (hadron beams), PAKHRA in Lebedev Inst. (electrons up to a few hundred MeV) and the Synchrocyclotron SC-1000 in PNPI (protons up to 1 GeV, secondary mesons). The capabilities of the SPS and PS beams at CERN are currently being used for tests. The possibility of using electron beams from the LUE-75 (AANL, Armenia) is under discussion.

A straight section of the NICA collider ring in the SPD hall can also be used for tests at the first stage of the collider operation.

Q7: Human resources for DAQ/computing

Q7: The DAQ seems to be the most demanding subsystem of SPD experiment. It is not clear that there are enough human resources in collaboration to implement the described DAQ/computing system, both in hardware and in software (algorithms). Please, comment on the need and possibility of extending collaboration specifically for computing needs. Please, show the schedule how DAQ/computing is planned to be implemented in preparation to stage 1.

Currently, the DAQ and software teams have enough people to build a prototype, but not enough to build a full-scale system. Therefore, during 2024-2025, a gradual increase in the relevant groups is expected, both through the recruitment of JINR and within the framework of the SPD collaboration…

At the moment, JINR is discussing the creation of a NICA Computing Collaboration, which will allow pooling some of the resources and personnel for all experiments at NICA, specifically in core computing services.

A preliminary work plan is provided in the supplementary document.

Q8: Preparation for stage 2: ECAL, FARICH

Q8: The stage 1 is an important part of experiment, but is should be considered as intermediate stage. Having only the stage 1 does not justifies the SPD experiment. It seems that the design of the major stage 2 subsystems, e.g. Ecal and Farich, is still conceptual. Please, comment on when the technical design for these subsystems is planned.

The shashlik-based ECAL is a well-elaborated system. The JINR team has experience in building such a calorimeter (with slightly different sampling) for the COMPASS experiment (ECAL0). Some number of test modules were produced and tested. The main uncertainty for this detector at the moment is the way in which it has to be assembled. There is also no complete clearness on the electronics. We would note that the possibility to install at least part of one of the calorimeter endcaps already in the first stage of the experiment is discussed.

The FARICH detector proposed by the BINP group is really new to us, it was missing from the CDR. There is extensive R&D activity on it. We hope to have a full understanding of this subsystem in the next two years.

Q9: The Computing and Offline Software

Q9: The Computing and Offline Software part describes the challenges brought by the high event rates and big data volume of the SPD experiments, and proposes to adopt some machine learning based algorithms for fast reconstruction and full reconstruction, such as tracking, clustering and muon identification etc. However, there is no performance presented in the TDR. Furthermore, we did not get the information about what status of the whole offline software system is. Does the offline data processing chain, including the full detector simulation and full event reconstruction, has been built for M.C. data production?

The performance of algorithms based on machine learning has been studied for tracking and FARICH. The key problem of ML-based algorithms, though, is not so much performance as control of systematic bias. The key problem of ML-based algorithms, though, is not so much performance as control of systematic bias.

There is a complete chain of simulation and reconstruction in the SpdRoot software (based on FairRoot framework). A new set of offline software is being developed based on the Gaudi framework. The transition from SpdRoot to the new framework is expected to take place during 2025.

Q10: Coherence of stage 1 and stage 2

Q10: Are the interfaces between stage 1 and stage 2 of the entire SPD construction clear enough? What resources (such as space, water, electricity, gas and public facilities) need to be reserved for stage 2 in the design and construction of stage 1? Is there no any confliction in constructing stage 2 in the future after the completion of stage 1 construction? Do you need to remove some components from stage 1 and proceed with the installation of Stage 2?

We consider our setup of stage-1 as partially equipped setup of stage-2. The power frames of stage-1 will be the same as for stage-2.

The stage-1 MicroMegas detector occupies the same volume as a silicon tracker that will replace it later in stage-2. We plan to start with a beam-pipe made entirely of aluminum, which will be replaced to beryllium at stage 2. Another difference between these two stages is the passive absorber, which we plan to install in the ECal power frame at the beginning of the experiment. In the final stage, these absorbers will be replaced by active ECal modules.

The power sufficient for fully equipped detector will be available from the very beginning of operation.

Q11: Mechanical design

Q11: In TDR, the overall mechanical and structural system is still relatively preliminary, even lacking. Are the spatial dimensions, mechanical and structural interfaces of each system designed, determined, and optimized? Is there no contradiction in areas with limited space, such as collision zones, rib areas where the bucket and end-cap intersect? Is there any relevant mechanical analysis that needs to be supplemented?

The mechanical and structural system is still under development at the moment. At the end of autumn, we plan to complete the development of a 3D model of the RS system, which is used as a general structure and support for the detector subsystems installed inside. By next summer (2025) we should have a complete design of the mechanical and structural system for the first stage of the experiment.

Summary from SPD DAC (1)

- We congratulate the collaboration for the great works done over last years
- We are thankful to the collaboration for the presentations, additional materials and comprehensive answers to our questions
- SPD is an ongoing project and the presented TDR does not represent the final description of the SPD setup. Nevertheless it is a well-prepared and comprehensive document which provides enough information for the review.
- We recommend to the PAC to approve the current version of the TDR assuming that finalization of the subsystems configuration will naturally take place at the next stage of elaboration.
- We haven't identified any particular item which would put under risk the whole project.
- We fully support the staged approach to the development of experiment and find it important to have the detector ready for stage 1 operation as soon as possible

Summary from SPD DAC (2)

- We support the idea of installing parts of ECAL (that can be ready in time) for the stage 1 operation
- We recommend to put the highest priority to finalizing the complete assembly and interfaces scheme for the full detector setup. The construction for major subsystems can start only after.
- We recommend to switch to procurement/construction for the materials and the parts of detector for which the final design is ready
- Development and production of detector electronics seems to be the key risk factor.
- We find the computing infrastructure as the one of the most challenging factors for the experiment and support the idea of sharing resources between all NICA experiments
- We recommend to organize joined working group between SPD collaboration and NICA accelerator team to enhance detector-accelerator collaboration in preparation for stage 1 operation