

Review of the project “Search for dark sector in experiments at the CERN SPS (02-1-1096-2-2010/2026)”: Proposal for Extension of JINR Participation in the NA64 experiment at SPS

The NA64 experiment is a fixed-target experiment at the CERN SPS designed as a hermetic detector to search for Dark Sector physics in missing energy events from electron/positron, muon and hadrons scattering off nuclei. In the hypothesis of nonzero kinetic mixing between the Dark Sector so-called dark photon A' and Standard Model photon, the experiment is sensitive to the invisible, semi-visible and visible decays of the dark photon. The NA64 approach combines beam dump and missing energy technique. The number of expected signal events is roughly proportional to the squared coupling constant of the dark photon production in the target. This is significant advantage with respect to the classical beam dump experiments the sensitivity is proportional to the fourth power of the coupling constant since the dark photon must decay or interact with the detectors to be registered.

The JINR group is responsible for

- 12 double layer 6mm straw tube chambers with 200x200 mm² (used for electron & muon setups); 7 double layer 6mm straw chambers with a size 1200x600 mm² (used for μ setup);
- full support of the DAQ, straw chamber online-monitor;
- theoretical investigations, M-C simulation, data taking and analysis.

The JINR group consists of 12 researchers, who are co-authors of the papers, and 3 members of the NA64 technical support. The FTEs are distributed among the detector operation & support – 3.0, analysis and MC simulation – 3.0, and theory – 0.5.

NA64 has collected significant amount of data: $\sim 10^{12}$ electrons on target (analyzed $\sim 3.4 \times 10^{11}$ eot), $\sim 5.0 \times 10^{10}$ positrons on target, $\sim 4 \times 10^{10}$ muons on target, and $\sim 2 \times 10^9$ pions on target. There are 33 publications in the period 2020-2022, including referenced journals, conference proceedings, scientific reports, and general public articles. The JINR group is very active in the analysis of the data, in the conference participation, and in the preparation of articles.

The plan until LS3 is to accumulate as many as possible electrons on target (up to 5×10^{12}) and use the positron mode to enhance the sensitivity in the higher A' mass region. After LS3 the experiment would then continue data taking to accumulate $\sim 10^{13}$ muons on target to explore the A' higher mass region and $\mu \rightarrow \tau$ and $\mu \rightarrow e$ LFV processes. In addition, a feasibility study to explore dark sectors coupled predominantly to quarks using the missing energy technique is planned and potentially implemented after LS3.

The requested budget for the three years 2024-2026 is 426 kUSD and seems adequate to the planned activities.

The review of the referee A. Olshevskiy is positive and supports the requested extension. It underlines the large physics potential of the project and the significant role of the JINR group in the overall NA64 activities – hardware, DAQ, data taking and analysis.

I completely agree with this opinion and propose to extend the JINR participation in the NA64 experiment in 2024-2026. At the same time, I would make the following remarks:

- There are some risks for the project, as mentioned in the proposal:
 - The possible reduction of the beam time for the SPS experiments, considered as mitigation for the impact of the electricity prices on the CERN budget.
 - The possibility for some restrictions on the collaboration between CERN and JINR.
- The fraction of analyzed data sample is roughly one third which needs additional clarification. This is especially true since no computing resources are requested.
- The budget table in Annex 3 specifies 15+37 kUSD for materials each year, but there is no explanation what the meaning of the two numbers is.
- Annex 4 contains a lot of repetitions compared to Annex 3. I suppose that the budget presented there is the budget for the previous three years (2021-2023?), however this is not clarified. In both Annexes it is better to have the actual years instead of year 1, year 2, etc.
- It would be good to use one and the same name for the NA64 project in all the documents and the presentations.
- I am grateful to the authors of the article [“Search for light dark matter in the NA64 experiment”](#) *Physics Uspekhi 64 (12)* - S N Gninenko, N V Krasnikov, V A Matveev for the detailed and useful overview and propose to include this paper to the list of NA64 publications.

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18/06/23