# Review of the project “Search for dark sectors in missing energy events”: Proposal for Extension of JINR Participation in the NA64 experiment at SPS

**The NA64 experiment** is designed to probe the Dark Sector physics in missing energy events. It has broad research program with e-, μ, π, Κ, and p beams at SPC. The search for invisible decays of dark photons, invisible decays of (pseudo)scalar mesons and interactions producing invisible final states is based on innovative approach, where the active beam dump is combined with missing energy technique. The advantage of this approach is that the number of signal events is roughly proportional to the squared coupling constant of the dark photon production in the target. In a classical beam dump experiment the sensitivity is proportional to the fourth power of the coupling constant since the dark photon has to decay or to interact with the detectors in order to be registered.

**The JINR group is responsible** for the design, production, tests and installation of 14 straw tube chambers, together with their data acquisition software, raw data decoding, online monitoring and visualization, reconstruction and Monte-Carlo simulation. The members of the group participated in the data taking runs and took care of the operation of the straw tube detector.

**NA64 results**: During the first stage of the experiment in 2016-2017 the experiment collected 14.7x1010 events using 100 GeV electron beam. The results of the first stage have been published in 4 articles in journals with high impact. In addition, 9 publications have been prepared to describe the technical aspects of the experiment. In 2018 the experiment was equipped with new straw-tube trackers, with VETO against hadron electro-production in the beam material upstream the ECAL, and with zero-degree HCAL for the rejection of events with hard neutral from upstream e- interactions. In 2018 NA64 collected 2х1011 events in a search for the invisible mode and 3х1010 events for the visible mode, the data are being analyzed.

**NA64 upgrades** for the run in 2021 are designed to improve the reliability of the detector and the trigger/DAQ live time. The combined improvement will reduce the experiment’s overall deadtime by 10%. To increase the overall signal efficiency and improve background rejection the following upgrade of the setup is planned:

1. additional number of the MM, GEM, ST stations are planned to be installed. A possible use of Si pixels as the tracker for the X → e+e− decay search might also be considered.
2. two fast beam hodoscopes in the upstream part of the setup
3. higher transversely segmented SRD detector with improved readout
4. large Veto HCAL (VHCAL) in front of the ECAL to reject large angle neutral secondaries from the upstream e− hadronic interactions
5. further improvement of the DAQ and the analysis program are foreseen to ensure a substantial data collection of 1012 events in 2021.

**The JINR group consists** of 8 researchers, who are co-authors of the papers, and 5 members of the NA64 technical support. The total FTE of the researchers is 2.4, and the total FTE of the technical staff is 2.3.

**The plans** of the JINR group are to participate in the reinstallation of the equipment at H4 channel of the SPS until its completion, to develop new large area straw tube chambers for the muon run in 2021, to work on the data analysis, data reconstruction and MC simulation. Some R&D with cosmic and ion-sources aimed at the improvement of the chamber characteristics, tests of electronics and DAQ modernization are foreseen together with the preparation of stage 2 proposal.

**The requested budget** for 2020-2022 is 360 k$: 145 k$ for materials, including 45 k$ common funds; 95 k$ for equipment; 120 k$ for travel expenses, and in my opinion is adequate to the planned activities. The total amount includes 105 k$ special contribution from Belarus, which is sign of recognition for the project.

**The reviews of the referees E. Dorokhov and S. Movchan are positive and support the requested extension.** They note that higher data statics in the planned extension will help to probe the most popular sub-GeV dark matter models. They also appreciate the significant contribution of the JINR group to the experiment and the essential role of the JINR physicists in the project.

**I completely agree with the opinion of both referees and propose to extend the JINR participation in the NA64 experiment in 2020-2022**. At the same time, I have the following remarks, partially based on the observations of the two internal reviews:

* The number of FTE should be higher for an efficient collaboration;
* The members of the JINR group should present the NA64 result at conferences or seminars;
* The participation of young researchers and PhD students in the work of the experiment would be very beneficial;
* The SWOT analysis of the proposed extension is not carried on. It should address the scientific merit of the project, for example provide a comparison with existing and planned beam dump experiments. It should discuss the weaknesses, for example the ones experienced in the first stage of the project, or more general questions like when it would become clear if any additional extension made no sense. It also should discuss the opportunities to provide feedback to other dark matter searches, and at the end discuss what are the difficulties/threats, for example that no signal is observed.

Peter Hristov

18/06/19