Reference on prolonging project NA61/SHINE in 2019-2021 years (JINR participation)

The offered project is a continuation of successful participation of the JINR group of employees from the Laboratory of High Energy Physics named after V.I.Veksler and A.M.Baldin and from the Laboratory of Nuclear Problems named after B.P.Dzelepov (JINR) in the experiment NA61/SHINE (SPS Heavy Ion and Neutrino Experiment, CERN) at the Super Proton Synchrotron (SPS).

NA61/Shine is a multi-purpose experiment to study hadron-proton, hadron-nucleus and nucleus-nucleus collisions. The broad range momentum of beam particles, from pions to lead nuclei, together with the large acceptance and high resolution NA61/SHINE detector gives a unique opportunity to perform the needed measurements.

This document gives a review of the physics research programme on relativistic nuclei interactions and describes unique experimental results obtained during the previous two years with active participation of the JINR employees in the project NA61. There are also plans of the joint work in the framework of the experiment for a period of 2019-2021 years.

First of all, now it is necessary to carry out analysis of a huge number of the accommodated data, perform modernization of the set-up and provide the performance of the runs in 2018.

The experiment carries out a comprehensive and consequent study of hadron interactions starting from elementary nucleon-nucleon processes till collisions of heavy ions having different atomic numbers and beam energies (20A·GeV-158 A·GeV).

The participants of the project are co-authors of numerous publications and presentations on this topic which are widely quoted in the world literature.

Further participation in experiment NA61 will allow the physicists to continue systematic studying of nucleus-nucleus interactions starting from light nuclei till the heavy ones including the nuclei of the middle sizes. For this programme the studies at the set-up NA61 are extremely valuable and still beyond the competition due to unique parameters of the facility and availability of nuclei beams at SPS in CERN.

The physical programme of the NA61 at SPS, CERN, includes the following main items on experimental data taking and analysis:

• study of energy dependence of hadron properties in p + p и p+A interactions, as well as in nucleus-nucleus collisions to study characteristics of these processes and search for the proof of the critical point existence in the strongly interacting matter;

• study of hadron properties in proton-proton and proton nuclei interactions to understand better the nucleus-nucleus reactions;

• study of hadron production in hadron interactions necessary for neutrino and space experiments.

It is important to emphasize that the beam momentum range provided for NA61/SHINE by SPS is very important for the heavy ion, neutrino and cosmic ray

communities. Therefore there is a world-wide effort to construct new facilities providing ion and hadron beams in the CERN SPS beam momentum range. They are: the fixed-target facilities at FAIR, Germany, and J-PARC, Japan, as well as the collider facility NICA, Russia. They will start operation after the results needed for the project are completed. The data from the collider facilities are typically complementary to the corresponding fixed target results. In particular, charm hadron measurements are only possible at the fixed target facilities providing the collision energy and data taking rate to be high enough. NA61/SHINE is the only experiment which carries out the requested measurements in the near future. Moreover, the needed operation of NA61/SHINE beyond Long Shutdown 2 would allow physicists to efficiently extend the programme of new measurements, if necessary.

In addition, JINR group participation in the NA61 experiment is necessary in the framework of training young professionals for the NICA project. On physics close to the NICA programme, in frame of the NA61 project there are two doctoral and two candidate dissertations defended. In 2017 V.Kolesnikov defended his doctoral dissertation on the study of the light nuclei yield in nuclear interactions. Now he is one of the leading physicists in the NICA project.

From the mentioned above it is evident that participation of the JINR group in NA61 experimental data analysis and new measurements on this set-up are considered to be fruitful and should be recommended to prolong the JINR group participation for the next period of 3 years.

Modest financial requests are quite justified to obtain physical results and, as expected, they will be a significant contribution to the research programme of JINR.

It is necessary to stress that JINR participation in the experiment NA61 is very important since the research programme in this experiment lies in the main stream of the long-range programme in the field of relativistic nuclear physics at JINR. It is complementary to the studies being carried out at the Nuclotron (JINR), RHIC (BNL) and the obtained experimental results are needed for planning the research at the acceleration complexes of NICA (JINR) and FAIR (GSI).

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20.02.2018