NARODOWE CENTRUM BADAŃ JĄDROWYCH
National Centre for Nuclear Research
Świerk
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Review of the JINR ALICE project for 2020-2022

The aim of the ALICE project is to study strongly interacting nuclear matter at extreme energy densities. The QCD predicts that, at sufficiently high energy density, there will be a transition from hadronic matter to a plasma of deconfined quarks and gluons - a transition which in the early Universe took place in the inverse direction after the Big Bang and which might still play a role today in the core of collapsing neutron stars.

Extrapolation of the experimental findings obtained at SPS and RHIC to the LHC energies together with the LHC results demonstrate that all parameters relevant for the formation of the Quark-Gluon Plasma (QGP) will be more favourable for its production at the LHC: the energy density, the size and lifetime of the system, and the relaxation time, all significantly increase.

The JINR belongs to the founding members of the ALICE experiment, being the only dedicated project for studying the QGP at the LHC.

The JINR contribution to the construction of ALICE detector consists of the designing a very large conventional dipole magnet and construction of its 800 tons iron yoke, manufacturing and testing the drift chambers for the transition radiation detector and procurement and testing of crystals for the electromagnetic calorimeter.

Since the completion of the LHC, JINR ALICE group takes the active role in the data taking and analysis, preparation of publications and in the GRID development. In particular, the JINR team intends to continue working on and further develop the following physics topics:

1. Investigation of femtoscopic correlations.

This topic originated by Kopylov and Podgoretsky at Dubna has a long tradition in the JINR activity. The new developments in this field, currently underway in the JINR team, are very encouraging and certainly merit particular support. After completing and publication of the 1-D analysis for pairs of identical charged kaons in p-p interactions and 1-D and 3-D analysis in Pb-Pb collisions, the main attention of the JINR team were concentrated on investigation of nonidentical charged kaon pairs in Pb-Pb and p-Pb collisions. The Final State Interaction model of R. Lednicky and V. Lyuboshits (JINR) was used for the K+K- femtoscopic study in which the invariant radius of particle-radiation-source is included as a parameter. The other parameters of the model were the mass and the width of the f0 resonance and contributions of ϕ meson production in the quark-gluon and hadronic phases. It was found that for the reasonable values of f0 parameters and production cross-section of ϕ meson in the hadronic phase, the extracted invariant radius is close to the one obtained before for the identical charged-kaon pairs using the different quantum statistical scheme. The results obtained for charged kaon pair production in the p-Pb collisions show that invariant radius is close to the one measured in p-p interactions at the same event multiplicities. These results disfavour models which incorporate substantially stronger collective expansion in p-Pb collisions compared to the pp ones. To perform similar comparison with Pb-Pb collisions requires larger than currently available statistics which is also necessary for the 3-D analysis. Continuation of the femtoscopic analysis for the already collected data together with those stored during Run-2 at the LHC requires the active participation of the experienced JINR team.

2. Study of quarkonium production in dimuon decay mode.

The physics program of ALICE includes studies of the charmonia and bottomonia production in p-p, p-Pb and Pb-Pb collisions. The JINR team is responsible for the important part of these studies - the creation of new and update the existing Monte-Carlo generators to simulate the different processes for the heavy flavour hadron production and dimuon decay. These generators will be used for the experimental study of quarkonia production with the high statistics data obtained in ALICE during the Run-2 of the LHC. The interesting new thermal model was suggested by the JINR team based on the Tsallis distribution and the blast-wave model. This model describes well spectra of pions and quarkonia productions in p-p collisions in the very wide region of energy from 5 GeV to 13 TeV. The plan to apply this model for the p-Pb and Pb-Pb collisions looks interesting.

3. Investigation of Ultra-Peripheral Collisions (UPC) of heavy ions.

The physics program of the ALICE includes also studies of the photon-induced UPC which occurs when ions collide at impact parameter greater than the sum of nuclear radii. The electromagnetic field in the UPC results from a flux of virtual photons with intensity of the field proportional to the ion-charge squared. The LHC in heavy-ion mode works as a powerful source of quasi-real photons.

The JINR team takes the active participation in the analysis of vector meson photoproduction (photon-Pomeron exchange) which can occur either coherently off the whole nucleus or incoherently off nucleons. During the 2017-2019, the analysis was carried out for single J/ψ and $\rho 0$ coherent photoproduction in Pb-Pb collisions at 5.02 TeV. Very detailed selection of the resonances allowed to obtain the differential cross sections with good accuracy. A good agreement was observed between the experimental data the theoretical model predictions with moderate gluon shadowing contributions in the nuclei. The future plans for investigation of four particles with resonance $\rho 0(1450)$ and double vector mesons productions are very interesting.

4. Maintenance of GRID-ALICE analysis in the JINR.

The important part of JINR activity is the maintenance of GRID-ALICE analysis. The large enough resources of the computing farm with a good efficiency provide a contribution of 15.8% to all Russian centres giving the JINR a leading position among Russian tier-2 centres. To maintain this role would be important for the JINR.

Concluding, I would like to emphasize that the participation of the JINR team in the realization of the JINR physics program is of the highest value for both, the JINR and the ALICE Collaboration. The JINR physics program is well balanced and based on the existing broad experience of the JINR team. The JINR participation, coordinated by Professor A. Vodopyanov, in the dedicated heavy-ion experiment ALICE at the CERN LHC is extremely important for the JINR scientific program and is highly valued in the ALICE Collaboration. Its continuation certainly merits to be given the highest priority for the next term of financing.

Prof. Dr. hab. Teodor Siemiarczuk