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Gold-gold interactions with the future NICA collider

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Interview to Vladimir Kekelidze by Luisa Cifarelli

The NICA project is the new “megascience” project of the Joint Institute for Nuclear Research (JINR), an international intergovernmental organization located in the town of Dubna on the banks of the Volga river, a hundred kilometers north of Moscow. It’s my pleasure to interview Vladimir Kekelidze, who is driving the NICA construction effort.

What is NICA, in a nutshell?

NICA is an abbreviation of Nuclotron Based Ion Collider fAcility, which is being built at JINR. The main objectives of the project are to study the phases of nuclear matter, including quark-gluon, and their transitions at the maximum possible baryon density, as well as to study the spin structure of the nucleons (protons and neutrons).

A baryon density up to ten times the nominal one, which may only exist in the core of neutron stars, is expected to be recreated in gold-gold collisions at the energy up to 11 GeV per nucleon. The nucleon spin structure will be studied in collisions of polarized protons and deuterons at the energy up to 27 GeV in the center-of-mass system.

To reach these goals the NICA complex, made of an accelerator chain and three detectors, is under construction at JINR. The accelerator chain includes the Nuclotron, a synchrotron accelerating a variety of ions up to 10 GeV per nucleon, which was commissioned in 1993, and the booster and the collider that are currently under construction. All accelerators are based on the technology of super-ferric superconducting (SC) magnets developed at JINR in the eighties and now required for the construction of several facilities. A special workshop for the serial production of these SC magnets was put in operation at JINR in 2016.

What are the elements of the NICA complex already completed and what is the current state of the project?

The booster, a synchrotron with a circumference of 220 m, is fully assembled and integrated with an injection block consisting of an ion source and a HILAc (Heavy Ion Linear Accelerator). Its commissioning with beam is scheduled for December 2020. The collider with a circumference of 503 m will be located in a new building, which is under construction now. The construction of the building, which will contain the collider tunnel and two experimental halls for two large detectors, respectively called MPD and SPD, is due to be completed by the end of 2021. To meet the project schedule, civil engineering stages are envisaged to allow the installation of the collider and detector blocks in the completed building parts. Thus, the MPD hall has already been completed and the assembly of the detector large SC magnet has begun inside. The installation of the collider magnets will begin in early 2021. More than 60% of the collider magnets have already been produced at the workshop. The rest of the parts (RF stations, electron cooling system, and others) are being produced at the Budker Institute of Nuclear Physics (Novosibirsk) and other partner organizations.

The JINR NICA ring in May this year, with its two detector halls and on the right, in the background, the Nuclotron building.

Can you say a few words about the detectors that will be installed at NICA?

The detectors are: BM@N (Baryonic Matter at Nuclotron), operating with a beam extracted from the Nuclotron; MPD (Multi Purpose Detector), located at the first interaction point (IP) of the NICA collider; and SPD (Spin Physics Detector), located at the second IP.

International collaborations have already been founded to carry out the BM@N and MPD experiments.

A BM@N collaboration, representing 20 institutions in 10 countries, has started data taking with a startup configuration of the detector as early as 2018. More than 200 million events of carbon, deuteron, argon and krypton beam interactions with a variety of targets have been recorded in the first runs. The experiment will continue in the fall of 2021, when heavy ion beams with kinetic energy up to 4 GeV per nucleon will be available using the HILAc-booster-Nuclotron accelerator chain.

The MPD collaboration involves 40 laboratories from 11 countries. The experimental apparatus consists of a big SC solenoidal magnet with detectors inside: inner tracker, time projection chamber, time of flight system and electromagnetic calorimeter, two end cap hadron calorimeters and other systems. A magnet yoke of almost 700 tons is now being mounted in the MPD hall. The SC coil inside the cryostat, the trim coils and other magnet parts were produced at the ASG Supercoductors in Genoa. The cryostat with the SC coil is so large that it could be delivered to Dubna only by water. Currently a ship with a 110-ton cryostat package is on its way to St. Petersburg. Then, after customs clearance, it will be loaded onto a river barge, and the journey to JINR will continue along the northern canals, then along the Volga and Dubna rivers. This journey is very critical in timing because it must be completed before navigation closes due to winter frost.

The SPD collaboration is at the stage of foundation. The technical design project of the corresponding detector is expected to be ready in 2021.

Of course, in addition an appropriate infrastructure is needed. Does it already exist at JINR?

To ensure reliable and efficient operation of the accelerator and detectors, an appropriate infrastructure is being built. It includes a cryogenic system with a compressor station producing liquid nitrogen and liquefied helium with a cooling capacity of 10 kW at a temperature of 4.5 K, cryogenic pipelines of several km in length, a main electrical substation for 40 MW of consumer power and a series of substations that provide electricity to all units of the NICA complex. All parts of this infrastructure that are under active construction will be completed by the end of 2021.

Can you comment on the progress of the NICA project?

On September 15-16, the second meeting of the Cost and Schedule Review Committee (CSRC) for the NICA project, chaired by F. Ferroni (Gran Sasso Science Institute and INFN), took place via videoconference. The committee noted that NICA – scheduled to launch in the fall of 2022 – is a large and ambitious project. The CRSC reviewed the current state of the project, made recommendations for its implementation and strongly encouraged JINR for its successful completion. The COVID-19 pandemic had significant impact on JINR, like other laboratories in the world, and slowed down the progress of NICA. However, although the impact, in particular on the schedule, cannot yet be fully evaluated, JINR is determined to keep up the challenge.

Learn more about

Vladimir Kekelidze, Professor, Corresponding Member of the Russian Academy of Sciences, Vice-Director of JINR (Dubna), graduated from Tbilisi State University; since 1970 involved in particle physics experiments at U70 (IHEP) and at SPS (CERN) to study kaon decays, hyperon and charm particle hadropoduction, CP-violation; since 2010 leader of the NICA project; author/co-author of more than 300 papers.