Nebojša NEŠKOVIĆ*

NATIONAL, INTERNATIONAL AND GLOBAL APPROACHES TO SCIENCE AND TECHNOLOGY

Abstract: In November 2016, the World Academy of Art and Science (WAAS) launched the initiative to create a large research infrastructure project that would be focused on sustainable development of Southeastern Europe. The project would be realized using the model of the European Organization for Nuclear Research (CERN), Geneva, Switzerland. CERN was founded in 1954. Today, it is the largest laboratory for particle physics in the world. In 1956, a similar institution, the Joint Institute for Nuclear Research, was founded in Dubna, USSR. Currently, it is one of the largest research centers in the world devoted to particle physics, nuclear physics, and condensed matter physics. The CERN model was used in founding the TESLA Scientific Center (TSC), in Belgrade, Yugoslavia, in 1996 as well as the center under the name Synchrotron Light for Experimental Science and Applications in the Middle East (SESAME), in Allan, Jordan, in 2002. The former center, created to act in Southeastern and Central Europe, was devoted to science, technology and medicine with ion beams, while the latter one is concentrated on the same fields with beams of electromagnetic radiation. Unfortunately, TSC terminated its activities in 2006, due to refusal of the international community to support it. On the other hand, the use of SESAME will begin by the end of 2017, as a result of serious support by the same community. Here, we describe briefly the activities of these four research centers with the aim to uphold the proposal of the Vinča Institute of Nuclear Sciences, Belgrade, Serbia, to revive TSC in a similar form and with the modernized programs either through the WAAS initiative or with the support of Rosatom, the state corporation for atomic energy of Russia. This revival would be an additional proof that a dialectical unity of nationalism and globalism is a necessary basis for advancement and excellence on a wide front in science and technology. It would also provide very much needed cultural bridges between the nations in Southeastern Europe, some of them being in severe conflict since 1990 s, and, thus, additionally contribute to sustainable development of the region.

Key words: *Research infrastructure, accelerators, science, technology, medicine*

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* Vinča Institute of Nuclear Sciences,
University of Belgrade, Serbia
WAAS Secretary General
President, Serbian Chapter of the Club of Rome

INTRODUCTION

This contribution is related to the initiative of the World Academy of Art and Science (WAAS) to create a large research infrastructure project that would be focused on sustainable development of Southeastern Europe. The initiative was launched in November 2016 and supported by the European Organization for Nuclear Research (CERN), Geneva, Switzerland, in December 2016. It would be realized using the CERN model. After several meetings of the representatives of the governments of the countries belonging to the region during 2017, the kick-off meeting for the project should be held in January 2018 in Trieste, Italy.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CERN is the largest laboratory for particle physics in the world. It is located in the vicinity of Geneva at the border between Switzerland and France [1,2]. CERN was founded in 1954 by 12 European states. Today, its members are 21 states from Europe and Israel. Bulgaria, Greece, Hungary and Romania are among these states. Three states have the status of associate member in the pre-stage to membership, and four states are associate members of CERN. Since 2012, Serbia belongs to the former group while Slovenia obtained the same status in 2016. Japan, Russia and the USA have the status of observer in CERN, together with UNESCO and the European Commission. The FY Republic of Macedonia, Croatia and Montenegro cooperate with CERN on the basis of special agreements. About 4,300 engineers, technicians and other experts are employed in CERN, and about 12,800 scientists from many institutions worldwide use its experimental devices.

In CERN, a chain of six accelerators, a circular collider — LHC, a decelerator — AD, a mass separator — ISOLDE, and a neutron facility — nTOF, are in operation. Each of the six accelerators increases the energy of a beam of particles before delivering it to an experimental device, to the next accelerator in the chain, or to LHC. LHC is located in an underground tunnel of the circumference of 27

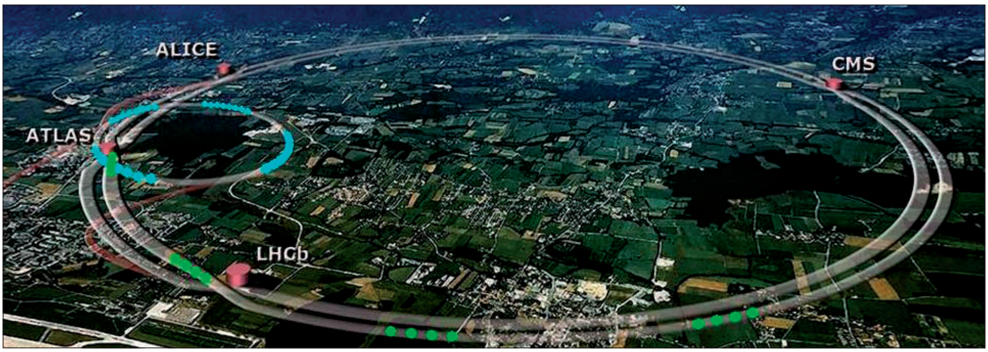

Figure 1. Scheme of LHC with SPS, and the positions of CMS, ATLAS, LHCb and ALICE, in CERN.

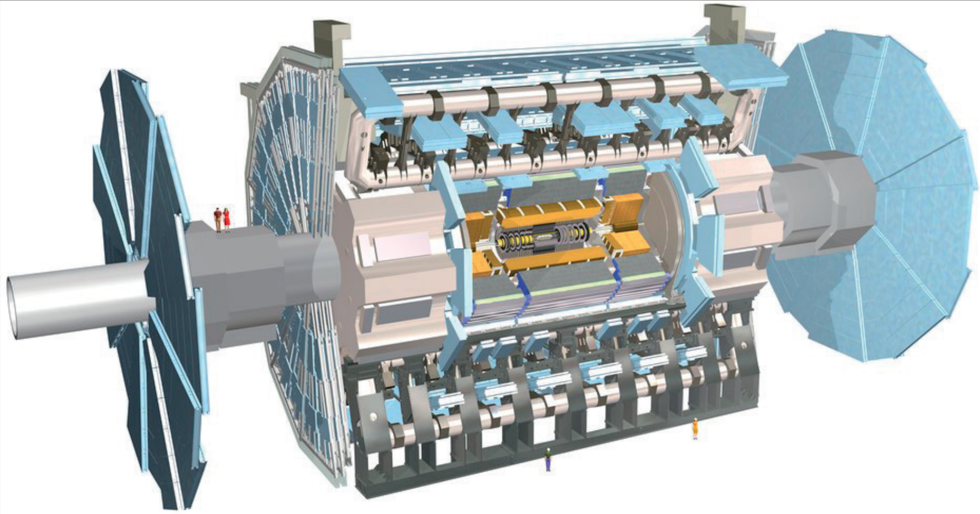

Figure 2. Scheme of ATLAS, in CERN.

km. It accelerates two beams of protons and/or lead ions in the opposite directions, which then collide in four regions along its circumference. In these regions, four large experimental devices are placed — CMS, ATLAS, LHCb and ALICE. Three smaller experimental devices are also connected to LHC. Each of the seven devices is a complex detector that registers some of the products of particle collisions, and, thus, enables exploration of a specific aspect of these collisions. Figure 1 shows LHC with the sixth accelerator in the chain (SPS) and the positions of the four large detectors, while Fig. 2 gives a scheme of ATLAS.

JOINT INSTITUTE FOR NUCLEAR RESEARCH (JINR)

In 1956, an institution similar to CERN, the Joint Institute for Nuclear Research (JINR), was founded by 11 states in Dubna, USSR [3,4]. Currently, it comprises 18 member states and six associate member states, and cooperates with numerous institutions worldwide on the basis of special agreements. JINR is one of the largest research centers in the world devoted to particle physics, nuclear physics, and condensed matter physics. It is composed of six laboratories and a university center. The staff of JINR totals about 5,000 people, including about 1,200 scientists, and about 2,000 engineers and technicians.

The main research facilities in JINR are a heavy ion synchrotron — Nuclotron, two heavy ion cyclotrons, and a pulsed fission nuclear reactor. Figure 3 shows the U-400 M cyclotron, which is used for discovering chemical elements forming the island of stability in the superheavy region of the periodic table of elements. The major research facility under construction in JINR is the Nuclotron-Based Ion Collider Facility (NICA).

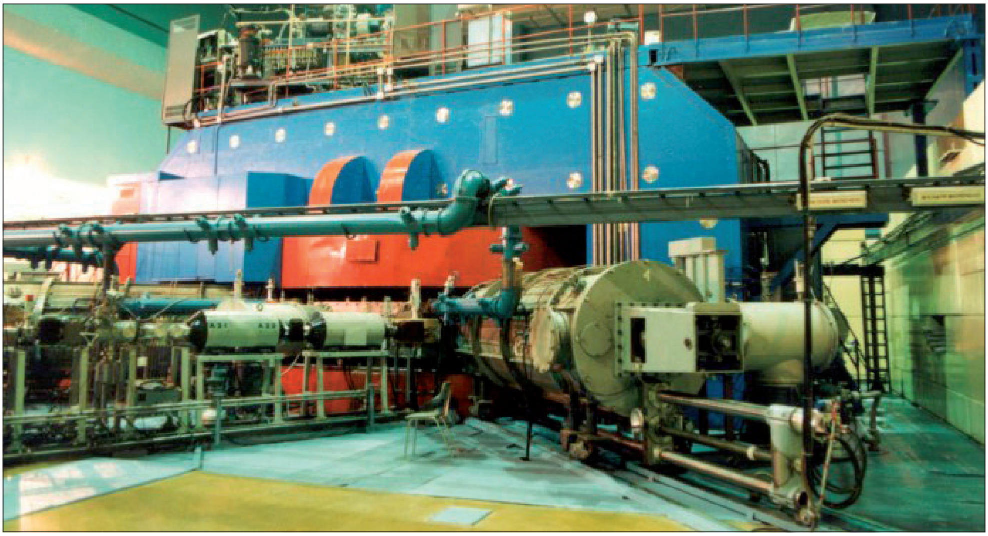

Figure 3. U-400 M heavy ion cyclotron, in JINR.

TESLA SCIENTIFIC CENTER (TSC)

In July 1996 in Belgrade, Yugoslavia, the TESLA Scientific Center (TSC) was founded as a center for research in physics, chemistry and biology, for development of materials and nuclear technologies, for production of radioisotopes and

Figure 4. Geographical locations of the institutions belonging to TSC.

radiopharmaceuticals, and for hadron therapy in Southeastern and Central Europe. That was based on the CERN model and was directly supported by CERN, JINR, the Oak Ridge National Laboratory (ORNL), Tennessee, USA, and the Government of Serbia. The principal facilities of TSC were the TESLA Accelerator Installation[5–9], in the Vinča Institute of Nuclear Sciences, Belgrade, Serbia, and the accelerator installation in the Cyclotron Center of the Slovak Republic, Bratislava. Each of the two facilities consisted of a medium-size cyclotron, two ion sources, and a number of experimental channels.

TSC was acting as an association of 15 scientific and educational institutions from Bulgaria, Greece, Hungary, Italy, the FY Republic of Macedonia, Romania, Serbia and the Slovak Republic interested in use and development of the two facilities. Figure 4 shows the geographical locations of these institutions. TSC terminated its activities in December 2006 due to refusal of the international community to support it.

SYNCHROTRON LIGHT FOR EXPERIMENTAL SCIENCE AND APPLICATIONS IN THE MIDDLE EAST (SESAME)

The CERN model was also applied in founding the center under the name Synchrotron Light for Experimental Science and Applications in the Middle East (SESAME), in Allan, Jordan[10]. That had been initiated by CERN, and has been being supported by UNESCO since May 2002. The members of SESAME are Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey, while its observers are 16 states worldwide and the EU.

The major facility within SESAME is a synchrotron where the accelerated electrons are stored. These electrons emit electromagnetic radiation that is employed

Figure 5. Building of SESAME.

for analysis of various samples for scientific or technological purposes. The facility is open for use to scientists, engineers and students from the Middle East and other parts of the world. SESAME was officially opened in May 2017, while the use of the facility is expected to commence by the end of 2017. Figure 5 shows the building of SESAME.

NEW TESLA PROJECT: SCIENCE, TECHNOLOGY AND MEDICINE FOR SUSTAINABLE DEVELOPMENT OF SOUTHEASTERN EUROPE

Following the WAAS initiative to form a large research infrastructure project focused on sustainable development of Southeastern Europe, the Vinča Institute has generated the proposal to revive TSC in a similar form and with the modernized scientific, technological and medical programs. The proposal is related to the completion of construction of TESLA and its use through the New TESLA Project: Science, Technology and Medicine for Sustainable Development of Southeastern Europe. Figure 6 shows the buildings of TESLA.

The completed TESLA should have three parts — FAMA, the H4 Facility, and the VINCY Facility. The original FAMA, which was commissioned in May 1998, comprised a heavy ion source, a light ion source, and a channel for modification of materials. In June 2010, the realization of a contract on the upgrading of FAMA began. The contract comprises the refurbishment of the original FAMA, the construction of an additional channel for modification of materials, the construction of a small cyclotron complex delivering protons of energies between 1 and 3 MeV, and the construction of two channels for analysis of materials. The

Figure 6. Buildings of TESLA.

Figure 7. Proton cyclotron complex within FAMA.

commissioning of the upgraded FAMA should be completed in June 2018. Figure 7 shows the cyclotron complex within FAMA. Currently, the user community of FAMA includes 20 groups from Serbia and five groups from abroad. It will be enlarged by a number of user groups from the region and other parts of the world.

The main part of the H4 Facility should be a commercial cyclotron delivering protons of energy about 18 MeV. The Facility will be used primarily for industrial production of radiopharmaceuticals for positron emission tomography (PET). These radiopharmaceuticals will be regularly delivered to medical institutions in Serbia. However, the Facility will be also used for experimental production of radiopharmaceuticals, also primarily for PET. The obtained radiopharmaceuticals will be delivered to medical institutions in the region.

The VINCY Facility comprises VINCY, which is a medium-size cyclotron, and five experimental channels. The machine had been designed to deliver proton beams of energies up to 73 MeV and heavy ion beams of energies up to 34 MeV per nucleon, to be used for basic and applied research in physics, chemistry and biology, for development of materials and nuclear technologies, for production of radionuclides and radiopharmaceuticals, and for proton therapy. In June 2013, it was decided to redesign VINCY to make it deliver only proton beams of energies between 30 and 75 MeV, and to modernize the programs of use of these beams. The currents of the delivered beams will go up to about 100 μA. These beams will be used for proton therapy of eye tumors, for radiation research in biology, chemistry and physics, for experimental production of radionuclides and radiopharmaceuticals, for research and development in physics of thin crystals, and for research and development in neutron physics. The proton therapy treatments and the produced radiopharmaceuticals will be offered to patients of medical institutions in the region. The user groups of the other experimental channels will come from the scientific and educational institutions in the region and other parts of the world.

The New TESLA Project should comprise the additional upgrading of FAMA, and the completion of construction of the H4 Facility and the VINCY Facility. The financial resources required for its realization should come either from the

European Commission, through the European Strategy Forum on Research Infrastructures (ESFRI), on the basis of the WAAS initiative, or from Rosatom, Moscow, the state corporation for atomic energy of Russia, on the basis of the memorandum of understanding signed with the Vinča Institute in June 2013. The use of FAMA should begin in July 2018, while the completion of construction of TESLA should last four years.

CONCLUSIONS

The successful developments of CERN and JINR in a long time and their present important contributions to research and development worldwide together with the successful establishment of SESAME, seriously supported by the international community, clearly demonstrate that advancement and excellence on a wide front in science and technology requires connecting and uniting the national, international and global approaches to these activities. In accordance with this and following the WAAS initiative to form a large research infrastructure project focused on sustainable development of Southeastern Europe, the Vinča Institute has prepared the proposal to complete the construction of TESLA, and make it a modern user facility open to scientists, engineers and students from the region and other parts of the world.

A successful realization of the New TESLA Project would be an additional proof that a dialectical unity of nationalism and globalism is a necessary basis for wide advancement and excellence in science and technology. This would also provide very much needed cultural bridges between the nations in the region, some of them being in severe conflict since the beginning of the 1990 s, and, thus, additionally contribute to sustainable development of the region.

ACKNOWLEDGMENT

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