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ILC ACTIVITY AT JINR

J. Budagov, Yu. Denisov, I. Meshkov, G. Shirkov, A. Sissakian, G. Trubnikov

Joint Institute for Nuclear Research, Dubna

JINR actively participates in new international mega-project ILC. JINR physicists are taking part in several fields of activity in ILC: works on photoinjector prototype, participation in design and construction of cryomodules, laser metrology, cryodiagnostics, etc. Joint Institute is one of the potential candidates for possible hosting of ILC in the region near Dubna. Status and progress of above-mentioned topics are discussed.

ОИЯИ принимает активное участие в глобальном мега-проекте «Международный линейный коллайдер» (ILC). Физики ОИЯИ участвуют в нескольких этапах проекта: в работах по проектированию и созданию фотоинжектора, в конструировании и разработке криомодулей, лазерного метрологического комплекса, криодиагностике и др. Объединенный институт является одним из возможных кандидатов на размещение ускорительного комплекса ILC в районе г. Дубны. Обсуждаются статус и перспективы вышеупомянутых областей деятельности ОИЯИ.

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INTRODUCTION

Prominent achievements of the fundamental science form the material and technical basis of the modern civilization. The crucial role here belongs to the elementary particle physics. Its main discoveries and laws are the result of complicated experiments, many of which have been carried out on beams of the elementary particle accelerators.

Expressing the undivided opinion of many leading scientists of the present time, the International Committee for Future Accelerators (ICFA) and the International Union of Pure and Applied Physics (IUPAP) declared about the major decision to join efforts of world scientific centers in construction of the advanced accelerating complex — the International Linear Collider (ILC) [1].

The unprecedented task of the ILC is to provide measurements in the field of elementary particle physics at the unprecedented accuracy in the wide region of maximally high energies of colliding particles (electrons and positrons). The possibility of energy variation (in the system of the center of mass of colliding particles from 500 to 1000 GeV) is of key importance to provide the maximal accuracy of measurements.

Today the ILC project is seen as a completely international scientific project, which must be developed, financed, governed, maintained and exploited in the framework of the wide international scientific cooperation organized properly.

The following main parameters of the facility are recommended at the international meeting in Snowmass. The luminosity at the energy of electrons 500 GeV is $2 \cdot 10^{34}$ cm$^{-2} \cdot$ s^{-1}. For

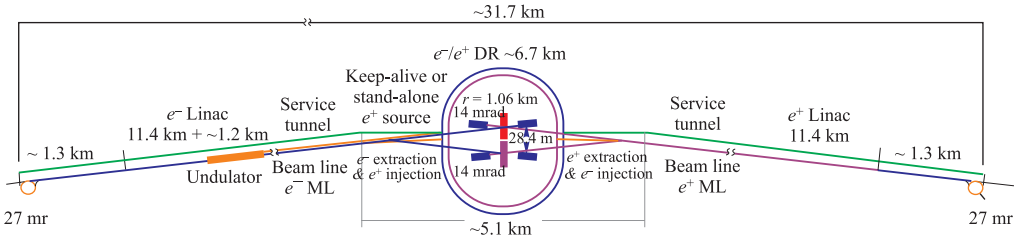

Fig. 1. Schematic layout of the 500 GeV machine

a 500 GeV facility based on the resonator of the TESLA type the maximal acceleration rate of all the 20000 resonators must be 35 MV/m and operating gradient — 31.5 MV/m at the length of each of two linear accelerators 10.6 km. At the subsequent increase of energy up to 1 TeV the resonators having the maximal gradient 40 MV/m and operating gradient 36 MV/m are recommended, which will lead to the increase of length for 9.3 km of each of two linear accelerators (Fig. 1). In this case, the length of the whole facility (total tunnel length) is about 40 km.

PROJECT ORGANIZATION

Organization and scale of the works to construct the ILC accelerator are unprecedented. Wide interstate relations at every stage of the project realization will allow the participants to use mutually the best scientific and technological achievements in their countries. Involvement of scientists and specialists from the Russian Federation (RF), JINR and its Member States in a high-tech project of the accelerator construction of such a scale will contribute to accelerated development of advanced technologies in these countries and, first of all, in Russia. By now, scientific, technological and organizational development in the framework of the ILC project has started and in progress. In accordance with the schedule, the basic and alternative configurations of the facility have been formulated at the end of 2005. As a result, the Baseline Configuration Document (BCD) has been prepared. On the basis of this document in the course of 2006 the designing is carried out, the cost is estimated and the physical program of investigations at ILC is formed. The modern official document on ILC project is Reference Design Report (RDR) — it was presented in February 2007 at Beijing (ILC GDE meeting).

The accelerator project is worked up by scientists and specialists from leading research centers and engineering companies of America, Asia, Europe, including Russian institutes and JINR in Dubna.

Cost of the Project. Currently, cost of the ILC project is estimated as 6.7 B$ (RDR document). By the GSPI (Moscow) specialist estimate, in case of placing the accelerator in the vicinity of Dubna, the total cost of building and assembly works of underground and overground facilities of the main construction will be 2.3 B$, according to the summary estimated calculation in prices of 2006. This cost includes the cost of tunnel construction of the linear accelerator itself and all of its technological systems and shafts about 1 B$.

The cost of power supply objects, which are necessary to erect in order to provide the electric power from the power supply sources at a reduced rate is 170 M$. According to the preliminary plans, the country interested in the ILC construction on its territory finances 25–30% of the project realization cost.

LOCATION

The contemporary international scientific community has shown a considerable interest to the initiative to construct ILC in Russia, in Dubna, where JINR has essential benefits and privileges as an International Intergovernmental Organization and has a unique experience of organization and successful realization of large-scale research projects based on wide cooperation of scientific centers and industrial enterprises of many countries. The main advantages of the ILC construction in Dubna are as follows:

1. The presence of JINR as a basic scientific and organizational structure. JINR is an international intergovernmental organization, which includes 18 Member States and 5 States, which are associated members. The agreement between the Russian government and JINR on the special status of the scientific organization has been put into effect by the Federal Law from January 2000;

2. Experienced personnel of JINR in accelerators, cryogenics, power supplies, etc. Infrastructure and workshops of JINR at the first stage of ILC project realization;

3. A good position in the European region. The town Dubna provides with all the necessary means of transport to deliver all kinds of equipment of the accelerator itself and its technological systems: highways, railways, waterways (through the Volga river to the Black sea, the Baltic sea, the Polar ocean). The international airport «Sheremetyevo» is situated at the distance of 100 km from Dubna;

4. The location in Dubna of the «Dubna» Satellite Communications Center (SCC), a unique center, according to the world standards. The Center is a branch of the Federal «Russian Satellite Communications Company», the largest satellite communications operator in Russia. The «Dubna» SCC closely collaborates with JINR. SCC is equipped by powerful fiber-optic channels providing the communication of information flows without distortions at the processing of scientific data received from accelerators of leading scientific centers throughout the world (CERN, FNAL, BNL, DESY, etc.).

5. The presence of up-to-date network and data-processing infrastructure in JINR and Dubna. In the course of 2003–2004 in JINR and the town the optical cables for data communication with the speed 1 Gbit/s were built. This formed a basis to create and start the Dubna–Moscow communication channel of 2.5 Gbit/s in 2005. In order to provide the effective participation of JINR in international and national projects, in the framework of this channel a segment with carrying capacity 1 Gbit/s was formed. The adequate development of external channels and networks of JINR and the town is planned: extension of the Dubna–Moscow channel up to 40 Gbit/s, extension of the international segment in the framework of the projects GEANT2, GLORIAD, increase of the carrying capacity of the channels up to 100 Gbit/s.

6. A Special Economic Zone (industrial + scientific) in the Dubna region (Edict of Russian Government, December 2005), provides unique conditions in taxes and custom regulations.

A positive reaction was received in preliminary discussions with the interested governmental persons and organizations in Russia.

The area is thinly populated, the path of the accelerator traverses 2 small settlements and a railway with light traffic between Taldom and Kimry. Possible «line» crosses only the railway to Savelovo (of low utilization) and the River Hotcha with a very small flow rate (Fig. 2).

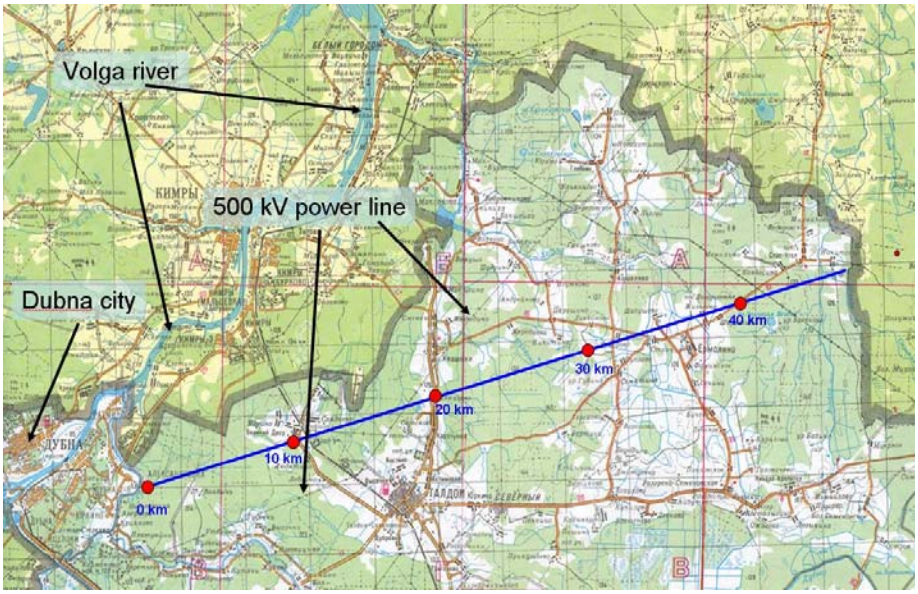

Fig. 2. Planned location for ILC near Dubna, Moscow region

There are no any national parks, biological reservations, any religious and historical places on the planned area. There are no new projects planned to develop on the allocated territory.

It is possible to avoid purchasing land and get the development area for free use without time-limit; like that has been done for the international intergovernmental organization JINR by the existing agreement between the JINR and the Government of the Russian Federation.

The climate is temperate-continental. The mean annual rainfall is 783 mm. The mean wind speed is 3.2 m/s. According to the climatic parameters, the territory of Dubna is considered to be comfortable.

The northern part of Moscow region and the neighboring regions have a developed system of objects of generation and transmission of electrical energy. There are first-rate generating stations: the Konakovo EPS (electric power station, ~ 30 km from Dubna) and the Udomlia APP (atomic power plant, ~ 100 km from Dubna). Two trunk transmission lines with the voltage 220 and 500 kV pass through the territory of Dubna. The investigation of possibilities of the power supply for the accelerator and its infrastructure with the total power up to 300 MW gives the following variant: construction of the power line — 220 kV, 35–40 km long, directly from the center of generation — the Konakovo EPS to the Central Experimental Zone of the accelerator with a head step-down substations 220/110 kV. It will require the

investment in larger amount but the cost of power obtained directly from the centers of generation will be lower for 40–50% (from 0.05 $ per 1 kW · h down to 0.02–0.03 $ per 1 kW · h in prices of 2006).

GEOLOGY AND RELIEF

The area of the proposed location of the accelerator is situated within the Upper Volga lowland. The characteristic feature of this territory is the uniformity, monolithic character of the surface. The existing rises of the relief in the form of single hills and ridges have smoothed shapes, soft outlines and small excesses. The territory of the area is waterlogged. The absolute marks of the surface range from 125 to 135 m with regard to the level of the Baltic Sea. The difference of surface marks is in the range of 10 m only on the base of 50 km.

This area is situated within the Russian plate — a part of the Eastern European ancient platform — a stable, steady structural element of the earth's crust.

The Russian plate, like all the other plates, has a well-defined double-tier structure. The lower tier or structural floor is formed by the ancient lower Proterozoic and Archaean strata of metamorphic and abyssal rocks, which are more than 1.7 billion years old. All these strata are welded into a single tough body — the foundation of the platform. The area of the ILC accelerator is located in the southern part of a very gently sloping saucer-shaped structure — the Moscovian syneclise. Alluvial deposits, i.e., fine water-saturated sands, 1–5 m of thickness. Below one can find semisolid drift clay of the Moscovian glaciation with exception of detritus and igneous rocks. The thickness of moraine deposits is 30–40 m.

The ILC linear accelerator is proposed to be placed in the drift clay at the depth of about 20 m with the idea that below the tunnel there should be impermeable soil preventing from the underlying groundwater inrush. It is possible to construct tunnels using tunnel shields with a simultaneous wall timbering by tubing or false work concreting. Standard tunnel shields in the drift clay provide for daily speed of the drilling progress specified by the project of the accelerator — it is needed approximately 2.5 years.

ILC ACTIVITY AT JINR

At the moment ILC activity at JINR has a very progress phase. A special dedicated scientific theme was approved by JINR Scientific Council and Program Advisory Committee in 2006 with the title «International Linear Collider: Accelerator Physics and Engineering». This theme intends R&D works in particle accelerator physics and engineering, construction of the free electron laser and other research facilities with the aim to prepare proposals for the project of JINR participation in international collaboration on construction of the International Linear Collider (ILC). Several projects are provided in the frame of this theme, they are the following: construction of photoinjector prototype, the LINAC-800 based test-bench with electron beam, development of RF system devices, development of diagnostic systems and built-in equipment, design of complex to study radiation stability/hardness, metrological laser complex, development and design of cryogenic modules of the 4th generation and test systems, preparation of technical base of cryogenic supply to test cryomodules of the 4th generation, calculation of electrical and magnetic fields of complex and supercomplex configurations, engineering survey and design works, development of magnetic systems of the ILC damping

rings, development of diagnostic systems of ultrashort bunches in the linear accelerator, experimental study of coherent radiation, construction of units for diagnostics of radiation from X-ray laser, development of diagnostics for large cryogenic systems. Personnel which is involved into ILC activity in Dubna is about 100 persons in the year 2007.

Works on the photoinjector prototype construction are in the following status: design of test-benches for preparation and transportation of photocathodes is at the final stage, numerical simulation of beam dynamics in photoinjector (ASTRA) and calculation of parameters of RF gun cavity (SuperFish) are in progress. The special agreement with IAP RAS (Nizhny Novgorod) on the construction of the laser system has been achieved. Works on the design and construction of this laser will start at the end of 2007. The project of photoinjector is realized in collaboration with BINP (Novosibirsk), IAP RAS (Nizhny Novgorod), KEK (Tsukuba), DESY (Zeuten).

Development of the test-bench prototype based on the electron linear accelerator LINAC-800 for diagnostic tools of beam parameters and transportation channels of the ILC unit prototypes is in progress. Development of the Free Electron Laser (FEL) design on the base of photoinjector and LINAC-800 is also provided. It is necessary to elaborate technical specification for undulator, optic resonator, and a diagnostic system of electron beam and radiation.

It was proposed to specialists from VNIIEF (Sarov) to investigate the possibility to produce a tube-type bimetal (stainless steel 12X18H10T + titanium VT1-0) by explosion welding in order to use it as a transitional load-bearing element in the construction of international linear collider's cryomodule. The following tasks were successfully solved: developing the pilot technical process for production of bimetal billet of tube type by explosion welding; researching a microstructure of the welded joint made by explosion welding; leakage testing of the welded joint at indoor and nitric temperatures.

Scientist from JINR actively works in design bureau at INFN (Pisa). The task is to learn software and standards of cryomodule elements design. Several design documents were created and successfully submitted by INFN and ZENON (Milan) in 2006–2007.

JINR developed test-bench at CERN for precise laser metrology. As a result, 0.5 micron precision of laser beam position measurement on the base of 40 m is achieved. At JINR it is planned to set this complex at the specialized building with two floor galleries of 250 m length.

Very fruitful collaboration is set with GSPI. All official documentations (Site Assessment Matrix, Work Breakdown structure, geological and geodetic characteristics) were made by GSPI in the frame of Contracts with JINR. Work is actively going on. It is planned to provide the following design works on civil engineering of ILC construction in Dubna (with assistance of Moscow region government): basic data acquisition for construction R&D works of ILC project, routing research with the description of characteristics of the offered line of the accelerator location and the infrastructure connected with it, to specify character of surface structures, to provide drilling of several control prospecting chinks for acknowledgement of prospective soil structure on the chosen line of the accelerator location.

CONCLUSION

Initiative in the decision of question of the ILC siting in Dubna could take jointly with JINR the leading European accelerator centers (DESY, CERN, INFN, and some others), and

also Russian Academy of Sciences and Budker INP firstly, Kurchatov RSC, Lebedev Physical Institute, ITEP, INR RAS, MSU as well as some other organizations and institutions. Such an offer obviously would get an approval from all sides of international community, if at the first stage of the project the main part of funding will take European countries and Russia. Of course it does not limit but assumes wide collaboration with other institutes and their countries.

Realization of such a wide scale project, namely in Dubna, will let Russia become in a perspective future by a leader and a center of attraction for scientists from Russia and neighbor countries. Another obvious factor is an attraction of significant investments and financial resources at all stages of the project including further exploitation of the new accelerator center during long years. Creation of ILC accelerator complex in a mentioned format of international collaboration will raise prestige of the fundamental science in total and the role of Russia as one of the world leader.

REFERENCES

1. http://www.linearcollider.org/