Particle accelerators being constructed and planned at superhigh energies

V. A. Yarba

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The studies being carried out at the present time in the field of high energy physics are a direct continuation of the studies which were carried out in their time in the field of nuclear physics and which led to the mastering of nuclear energy.

The problems are as follows: 1) to learn the structure of the particles of which atoms and nuclei are composed, i.e., the structure of neutrons, protons, electrons, and also of the particles which arise in various reactions (for example, neutrinos and muons); 2) to search for new forces which act at very small distances, and also to establish the relation between the known forces: electromagnetic, nuclear, and weak (and possibly to establish the unified nature of these forces); 3) to study the properties of space and time at very small space-time intervals.

The main instruments with which studies in high-energy physics (elementary particles) are carried on are charged-particle accelerators. In solution of various problems, use is made of both accelerators with fixed targets and accelerators with colliding beams of particles. In Table I we have listed the principal parameters of large accelerators which are in operation, being built, or being planned in various laboratories throughout the world. The table includes accelerators with a center-of-mass colliding-particle energy more than 10 GeV. It can be seen from Table I that in recent years a number of new accelerators at superhigh energy have commenced operation or construction in Western Europe and the USA.

In the USSR a number of institutes are making plans for an accelerator—storage-ring complex (UNK) for the Institute of High Energy Physics at Serpukhov—with proton energy up to 3000 GeV. The existing 76-GeV proton synchrotron at IHEP will serve as an injector to the UNK.

The accelerator complex being planned is a two-stage affair. The first stage accelerates protons from 70 GeV to 400 GeV and uses an iron-based electromagnet of the ordinary type. The second stage utilizes superconducting magnets with field up to 50 kOe, which permits protons to be accelerated to 3000 GeV with a ring radius of about 3 km.

The possibility of achieving proton-antiproton colliding beams has also been considered.

The plans provide the possibility of installation in the same tunnel of a second superconducting ring for the purpose of obtaining proton-proton colliding beams at an energy 3000 × 3000 GeV. With use of an additional elec-

TABLE I.

Proton accelerators				
	Energy, GeV	Intensity, p/cycle	Intensity, p/sec	Year of initial operation
FNAL, USA	500	$2\cdot10^{13}$	$2\cdot10^{12}$	1972
*FNAL, USA	1000	$5\cdot10^{13}$	$8\cdot10^{11}$	1981
CERN, Switzerland	400	10^{13}	10^{12}	1975
IHEP, USSR	70	$5\cdot10^{12}$	$6\cdot10^{11}$	1967
*(with booster)	70	$5\cdot10^{13}$	$6\cdot10^{12}$	1980
**IHEP, UNK, USSR	3000	$6\cdot10^{14}$	$8\cdot10^{12}$	

Proton-proton and proton-antiproton colliding beams			
	Energy, GeV	Luminosity, $cm^{-2}\,sec^{-1}$	Year of initial operation
CERN, Switzerland	26×26	$2\cdot10^{31}$	1970
*CERN, Switzerland ($\bar{p}p$)	270×270	10^{30}	1980
*BNL, USA	400×400	10^{32}—10^{33}	1985
*FNAL, USA ($\bar{p}p$)	1000×1000	10^{30}	1981
**IHEP UNK, USSR	3000×3000	10^{32}	

Electron-positron colliding beams			
	Energy, GeV	Luminosity, $cm^{-2}\,sec^{-1}$	Year of initial operation
DESY, West Germany	19×19	10^{32}	1978
*SLAC, USA	18×18	$1,5\cdot10^{31}$	1979
*Inst. of Nucl. Phys., Sib. Div., USSR Acad. Sci., Novosibirsk	7×7	10^{32}	1979
**CERN, Switzerland	70×70	10^{32}	

*—accelerators under construction; **—accelerators being planned.

TABLE II. Principal parameters of the IHEP accelerator-storage-ring complex.

	Stage I	Stage II
Total length	19.288 m	19.288 m
Tunnel cross section	5.6×3.6 m²	
Injection energy	70 GeV	400 GeV
Maximum energy	400 GeV	3000 GeV
Field strength at injection	~1.2 kOe	6.7 kOe
Maximum field strength	6.7 kOe	50 kOe
Length of cycle	78 sec	78 sec
Intensity of pulse	$6\cdot10^{14}$ p/cycle	$6\cdot10^{14}$ p/cycle
Length of dipole	5.8 m	5.8 m
Length of quadrupole	4 m	4 m
Total number of dipoles	2160	2160
Total number of quadrupoles	408	408
Vacuum	$3\cdot10^{-7}$ Torr	$2\cdot10^{-8}$ Torr
Power required	~100 MW	
Main particle-beam channels	p, $\bar{p}$, π, K, Y, μ, e, ν, γ	

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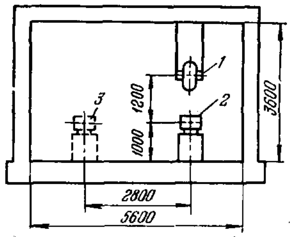

FIG. 1. Diagram of the cross section of the UNK tunnel. 1—Stage I of the UNK, 2—Stage II of the UNK, 3—storage ring. The dimensions are in millimeters.

tron storage ring it is possible also to obtain collisions of 10-GeV electrons with protons up to 3000 GeV.

The main parameters of the accelerator—storage-ring complex (UNK) at Serpukhov are given in Table II. The dimensions of the tunnel and a diagram of the arrangement of the magnets in the tunnel are given in the figure. It should be noted that the use of a new technology, that of superconducting materials, substantially reduces the size of the accelerator and the electrical power required.

Construction of the accelerator—storage-ring complex will open up extensive new possibilities for study of the fundamental properties of matter for many years to come.

The major scientific resource which has been built at IHEP will become the basis of the new scientific complex, the UNK. At all stages of the construction and use of the UNK it will be extremely important to develop broad collaboration of scientists from various institutes of the USSR and international collaboration.

[1]Trudy X Mezhdunarodnoĭ konferentsii po uskoritelyam saryazhennykh chastits vysokikh énergiĭ (Proceedings of the Tenth International Conference on high-energy charged-particle accelerators), Protvino, June, 1977.
[2]ISABELLE-BNL 50718, Brookhaven National Laboratory, 1978.
[3]Uskoritel'no-nakopitel; nyi kompleks IFVÉ (The IHEP Accelerator-Storage-Ring Complex): Preprint IFVÉ 78–134, Serpukhov, 1978.

Translated by Clark S. Robinson