THE SERPUKHOV 70-GeV ACCELERATOR

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This resumé is based mainly on a talk presented by E. A. Myae of the Institute of High Energies, Serpukhov, USSR before this conference, and on some other available data.[1] It is intended to give a general review of the present status of the Serpukhov 70-GeV accelerator as well as a compilation of the basic parameters of the machine.

The accelerator is located on a site surrounded by a beautiful forest about 100 kilometers from Moscow, near the town of Serpukhov. It is a strong-focusing proton synchrotron like the 33-GeV Brookhaven AGS and the 28-GeV CERN PS.

The most important part of the accelerator is, of course, the magnet assembly, which consists of 120 separate subassemblies or magnet blocks and has an average radius of 236 meters. The magnets form a FODO focusing system. The n value is 442, which gives a betatron frequency of 9.7 oscillations per revolution. The power supply system is of conventional design, i.e. motor generator sets with fly wheels and ignitron converters. The maximum field, 12,000 gauss, is reached in 3 seconds. The flat top of the magnet pulse, i.e. the duration of the peak field extends to 1 second and the frequency of pulsing is 8 times per minute. Demineralized water is used for cooling the coils; the criterion for the demineralized water is a resistivity of 500 kilohms per centimeter.

The vacuum chamber is made of stainless steel with a wall thickness of 0.4 millimeter. The dimensions of the vacuum chamber are 17 centimeters in the radial direction and 11.5 centimeters in the vertical. It is corrugated over its entire length for adequate mechanical strength. One hundred and twenty cold-cathode titanium pumps are used to pump down the vacuum system.

The injector is a linear accelerator with a terminal energy of 100 MeV; the preinjector that feeds the injector has a terminal energy of 750 keV. The ion source for the preinjector is a duoplasmatron source. There are 3 resonators in the injector with 216 drift tubes, and within the 216 drift tubes are quadrupoles that form a FODO system. The frequency for the linear accelerator is 150 MHz and the rf supply power is 15 MW. The injector is expected to yield a pulsed current of 100 mA with a pulse length of 40 microseconds. This is well within the range of the present state of technology. For injection into the main ring, both a pulsed inflector and a dc system will be employed, which will provide both single turn and multiturn injection. If one takes 100 MeV as the injection energy and a mean orbit radius of 200 meters, the required magnetic field is only 76 gauss. This field is quite low and may lead to some difficulties. For this reason an elaborate system of magnetic field correction, especially at the time of injection, will be employed.

A system is also provided to correct for the 10th harmonic both in radial and vertical field and for the 19th harmonic of the gradient. The high frequency system is of the conventional type. The frequency varies from 2.6 to 6.2 MHz. The machine will be operated on 30th harmonic of the revolution frequency. There are 53 accelerating points around the orbit, imparting a total of 190 keV to the protons. For control of the beam, there will be 85 pickup electrodes for each direction, and for the beam in the first turn a television screen will be provided for observation. A summary of the basic machine parameters is listed in Table I.

As for the present status of the accelerator at the site, all of the systems of the accelerator are now in place. All of the magnets are installed to an accuracy of ±100 microns, both vertically and horizontally. The magnetic system is in operation over half of the ring and is operating at its nominal parameters. Although each individual magnet assembly was carefully measured and calibrated before installation, magnetic measurements in the installed position over the entire periphery of the accelerator will be made again because it is felt that the knowledge of the magnetic fields, particularly in the linear sectors, is not adequate. Almost all the sections of the vacuum chamber have been tested at rated vacuum. The preinjector for the linear accelerator is in operation. All of the drift tubes are in place, and operating vacuum has been reached in the resonators of the linear accelerator. In the first resonator the design voltage has been reached, although this was accomplished without a beam in place.

Concerning the future prospects, it is expected that a complete first turn of the beam in the accelerator will be obtained this year, and it is hoped that the first physical experiments with the accelerator can be started next year. Immediately after the startup of the machine there will be available several beams of unseparated negative particles, such as π^-, K^- and antiprotons.

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*Since the manuscript of Dr. Myae's paper had not been received, Dr. Yuan was asked to prepare this resumé.

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Table I

Orbit length	1483.64 m
Effective radius of the orbit inside the magnet blocks	194.12 m
Length of normal block measured along its iron core	10.42 m
Length of shortened block	9.3 m
Number of blocks	120
Number of superperiods	12
Number of normal blocks in a superperiod	3F + 3D = 6
Number of shortened blocks in a superperiod	2F' + 2D' = 4
Length of short straight section	1.27 m
Length of medium straight section	2.62 m
Length of long straight section	4.86 m
Maximum field at equilibrium orbit	12 kG
Number of betatron oscillations per turn	9.7
Kinetic energy at injection	100 MeV
Transition energy (total)	8.9 GeV
Maximum proton energy	70 GeV
Field at injection	0.076 kG
Chamber half-height	57.5 mm
Chamber half-width (effective)	85.0 mm
Maximum orbit displacement at a unit momentum deflection $\Delta p/p = 1$	3.53 m
Maximum amplitude of forced oscillations	34 mm
Maximum amplitude of free oscillations	22.8 mm
Total weight of silicon steel in magnet	20,000 t
Total weight of aluminum in the windings	700 t
Energy stored in magnetic field	120 MJ
Peak supply power	100 MW
Number of cycles per minute	8
Rectified voltage at the beginning of the cycle	9230 V
Maximum rectified current	2 x 5750 A
Current rise time	3 s
Duration of pulse flat top	1 s
Expected intensity for first beam	10^{11} protons/pulse
Maximum intensity	2 to 3 x 10^{12} protons/pulse

Reference

[1]V.V. Vladimirski, L.L. Goldin, D.G. Koshkarev, E.K. Tarasov, B.M. Yakoviev, E.G. Komar, N.A. Monoszon, N.S. Strelzov, A.M. Stolov, V.A. Titov, I.F. Malyshev, A.V. Popkovitch, G.K. Gustov, V.V. Kulkov, A.L. Minz, S.M. Rubchinski, F.A. Vodopjanov, A.A. Kuzmin, V.A. Uvarov, V.F. Kuzmin, F.Z. Shirjajev, S.G. Filaretov and V.M. Zhadanov, Proceedings of the International Conference on High Energy Accelerators, Dubna, August 21-27, 1963.