Table I — Main Parameters of UNK.

Name	Unit of Measurement	First Stage	Second Stage
Total length	m	19288	19288
Injection energy	GeV	70	400
Maximum energy	GeV	400	3000
Injection field	T	0.117	0.670
Maximum magnetic field	T	0.670	5.0
Cycle duration	s	78	78
Pulse intensity	p/cycle	6×10^{14}	6×10^{14}

decreasing substantially the space charge effects in the second stage. In addition, various methods of beam scraping will be applied in the first stage facilitating an efficient (close to 100%) beam transfer into the second stage. To localize possible beam losses during acceleration in both stages, beam scraping stations are arranged in the long straight sections. Their length makes it possible to put in the necessary number of collimators after these stations and to suppress particle fluences arising there, down to the level suitable for the normal operation of the superconducting magnets. Should inadmissibly large beam losses occur, the accelerated beam will be extracted from the accelerator during one turn, with the help of beam abort systems, into the outer stoppers.

The operational cycle of UNK is the following. Successive beams of 5×10^{13} protons are accelerated in the U-70 by an RF field that has a frequency of 200 MHz, equal to the UNK accelerating voltage frequency. Stacking of 6×10^{14} ppp during 71.5 s is achieved by successive injection of 12 pulses from the U-70. The UNK circumference is exactly 13 times as long as that of the U-70, so that part of the first stage circumference is not filled with beam. This makes it possible to arrange "time slots" between the beam pulses, necessary to facilitate the operation of injection and extraction devices and thus to reduce particle losses. On completion of stacking, the beam is accelerated in the first stage up to 400 GeV and single-turn transferred into the second. The second stage comprises 20 s acceleration, 38 s beam extraction and 20 s field decay time.

Provision is made for correction stations to be installed in the long matched straight sections. To adjust betatron frequencies, chromaticity and equilibrium orbit, it is intended to position near the main quadrupoles universal superconducting correctors fitted with dipole, quadrupole and sextupole coils. Orbit correction is envisaged in both oscillation planes. 180 correctors working in either plane and with 0.5 mm r.m.s. orbit measurement resolution, the design correction accuracy is ±2 mm. As a result maximum beam dimensions at injection into the first stage are 50 mm in the vertical direction and 70 mm in the horizontal plane and during injection into the second stage — 42 mm and 50 mm, respectively. The dimensions of the vacuum chamber in the first stage are of two types, 47 x 87 mm^2, and 65 x 65 mm^2; the chamber of the second stage has an elliptical cross section of 60 x 70 mm^2.

Vacuum requirements in the chambers of the two UNK stages are determined by proton losses due to the residual gas. Mean pressure in the first stage should not exceed 3×10^{-7} torr nitrogen equivalent and 2×10^{-8} torr in the second. Preliminary calculations show that with the 20-40 K temperature of the chamber walls of the superconducting ring, a 2×10^{-11} torr vacuum can be obtained for hydrogen and $\sim 10^{-13}$ torr for other gases.

The UNK accelerating system has to provide 12 MV total amplitude at 200 MHz for the first stage and 17 MV for the superconducting ring, with maximum powers respectively of 6.6 MW and 18 MW.

Large Electron-Positron Colliding Beam Project

Based on a summary of his paper prepared by M. Vivargent, chairman of ECFA, that traces the rapid development of high energy physics since large machines became available for experiments. LEP is western Europe's choice for the next generation.

Among many other models, theorists Weinberg and Salam proposed, independently at the end of the sixties a model for the unification of weak and electromagnetic interactions. This model requires the existence of neutral weak currents. They were discovered in a neutrino beam at CERN in 1973 and 1974.

At the same time, S.S. Ting using a proton beam at the AGS of Brookhaven and B. Richter running the e^+e^- collider (SPEAR) at Stanford, discovered the J/ψ particle. J/ψ is considered as composed of a pair of one charmed quark and an antiquark. It is now generally admitted that hadrons exhibit at high mementum transfer, above a few GeV^2, a substructure and seem to be made of quarks and antiquarks.

Since 1974, subnuclear physics has known a very exciting period with new discoveries made with the large synchrotrons at Fermilab and CERN and with the e^+e^- colliders at Stanford and first DORIS then from the middle of 1978 with PETRA at DESY.

However, to establish the validity of the Weinberg and Salam model definitively, one has to discover the two charged vector bosons $W^\pm$ with a mass of about 78 GeV and the Z° meson with a mass of about 90 GeV, coupled respectively to the weak charges and the neutral currents. Their model also predicts the existence of a very special boson called the "Higgs" boson.

Since 1976, ECFA — the European Committee for Future Accelerators — a body representing the physics community of the CERN Member States — has carefully examined what accelerators should be built to maintain European subnuclear physics at the highest international level at the end of the eighties.

To solve the problems arising from the attempt to unify weak and electromagnetic interactions and from the development of a new theory of strong interactions called Q.CD, phycists of western Europe have unanimously proposed the construction of a large electron-positron collider called LEP.

CERN was asked by ECFA in May 1977, to study a e^+e^- collider with an energy up to 100 GeV per beam possibly located near the existing CERN site.

Early studies revealed great technical difficulties and heavy financial implications for the construction of a two-ring machine optimized for 100 GeV per beam. It was then decided to study carefully a single ring LEP optimized for 70 GeV per beam, with a radius of 3.5 km.

This second proposal, published in August 1978, was costed out at about 100 M SwFr, i. e. about half the original sum, and construction was estimated to take 5-7 years. It envisaged a machine built in a tunnel of 4m diameter cross-section, with eight straight sections, each of which was an interaction region. Four bunches each of electrons and positrons travelled in opposite directions and luminosity in the interaction regions was to be 10^{32} cm^{-2} s^{-1}. This proposal was based on the use of conventional iron-cored magnets but it was anticipated that later these could be replaced by superconducting magnets in order to achieve 100 + 100 GeV. It can be noted that the cost is only a little greater than that of the SPS, and LEP could be built inside the CERN budget if this was maintained at its present level by shutting down the 33+33 GeV pp collider and the 600 MeV synchrocyclotron and taking other austerity measures.

When the physics community had examined the new proposal, it pressed for the energy attainable with conventional techniques to be raised to 85 + 85 GeV and CERN was once more asked to review its design. « Version 8 » is now under study and due to be presented in time for ECFA to make recommendations on energy, radius and site by the end of the year. Major ring circumference has been increased to 30 607 m and studies are being made on how costs can be held down still more. One technique that is being investigated, for example, is the use of concrete magnets and although superconducting magnets are considered too advanced for this generation it can be anticipated that superconducting RF cavities would be introduced. Such studies are being made in close collaboration with all the main western Europe high energy physics laboratories. PETRA, for example will be used for tests on beam dynamics; Orsay is specializing in the injector and so on.

It is also proposed to build the machine in steps which would allow costs to be spread. First step would be 50 + 50 GeV at maximum luminosity, second 72 + 72 and third 80/85 + 80/85. First operation could begin in 1988.

It was noted that the synchrotron radiation losses at these energies would be respectively 5.76 MW, 13 MW and 20-24 MW per beam and a call has gone out to see whether at least a part of this radiation could not be put to good use.

Parallel to the machine studies led dy J. B. Adams, ECFA has set ap two working groups. One under, A. Zichichi is studying the experimental programme that might be associated with the machine and involves more than 360 physicists and engineers from all over western Europe. The second, chaired by J. Mulvey is looking at the consequences of such a project on subnuclear physics research in the CERN Member States. Abdus Salam's conclusions on the LEP project were that never before had there been a machine out of which you could be sure to get so much physics.

Machines Around the World

It is interesting to see how the several continents have become identified with different projects and one is seeing a world programme emerging where each major region specializes in something different.

China it seems, is concentrating for the present on a generously dimensioned 50 GeV proton synchrotron. At NAL Batavia in the USA, a second ring with superconducting megnets is being installed in the present 500 GeV annulus which will be used, to begin with as a proton synchrotron of 1 TeV (the Tevatron). The presence of two rings then gives opportunities for different configurations in the future and proposals have been made for pp: 1000 + 250 GeV and pp: 250 + 250 GeV or with cooling 1000 + 1000 GeV. The USSR multi-TeV fixed target proton synchrotron project UNK, with provision for later pp work at 2.2 TeV and then 6 TeV centre of mass energy is described in the preceding contribution. Other hadron colliders are: Isabelle in the US pp: 400 + 400 GeV; the CERN modified SPS facility for pp with 500 GeV in the centre of mass; Tristan in Japan with pp and 400 GeV in the centre of mass. LEP with e^+ e^- near 100 + 100 GeV is for the moment on its own. At Novosibirsk, however, a new approach is being considered, namely an e^+ e^- one shot linear machine which might be built in two stages, if the problems of accelerating very rapidly, intense and small phase bunches could be solved. First stage could be a 1 km long pair to give 100 + 100 GeV followed by a second step of three times the length and energy. Repetition frequency might be 10 Hz.

High energy physics it is clear is no longer following a single route and the diversification of machines is meaning that a world machine is giving place in physicists' minds to a world programme in which all the big laboratories are complementary and international in the widest sense.

European Synchrotron Radiation Facility

A summary of his lecture prepared by Y. Farge, of Orsay, chairman of the ad hoc committee set up by the European Science Foundation to study European synchrotron radiation requirements.

In 1976, the European Science Foundation, located in Strasbourg, set up a study group on synchrotron radiation under the chairmanship of H. Maier-Leibnitz. This group was composed of sixteen scientists, mainly from various synchrotron radiation facilities in western Europe which comprise : Bonn (Fed. Rep. of Germany), Daresbury (United Kingdom), Desy (Fed. Rep. of Germany), Frascati (Italy), Lund (Sweden), Orsay (Sweden). It presented the following recommendations and conclusions.

1. There will be a large discrepancy between the number of scientists who wish to use synchrotron radiation and the number of stations available on existing or proposed machines.

2. Existing high energy physics machines in general are not well adapted for synchrotron radiation work.

3. Energy consumption of some existing storage rings make their operation for synchrotron radiation work a very expensive proposition.

4. The design of many existing machines precludes the use of wigglers.

5. Strong efforts should be made to obtain dedicated beam time at existing high energy physics storage rings. Additional beam lines should be installed at these facilities to exploit them in an optimised way for synchrotron radiation research.

6. Small storage rings can be realised on a national scale.