FUTURE PLANS OF STORAGE RINGS AT CORNELL [1]

B. D. McDaniel

Floyd R. Newman Laboratory of Nuclear Studies

Cornell University

Ithaca, NY 14853, USA

I will speak first about the plans for CESR and then go on to talk about our plans for a 50 GeV storage ring CESR II.

The CESR ring has been operative now for nearly two years. During that period we have accumulated 20,000 nb^{-1} of integrated luminosity for experimental data taking in the upsilon region. You have heard here reports on the experimental results from that period of running time. During the last six months, averaging over scheduled shutdowns, machine failure, tuning and filling, we have obtained 85 nb^{-1}/day corresponding to a time average luminosity of 10^{30} cm^{-2} sec^{-1}. The maximum observed luminosity has been 4×10^{30} cm^{-2} sec^{-1} at 5 GeV. Luminosity is limited by the beam-beam effect and is about a factor of 10 below the luminosity predicted at this energy for the design tune shift of 0.05. The observed tune shift is 0.025.

Starting in the middle of July we shut down for 10 weeks to make some major modifications to the facility and detectors. In order to improve our luminosity we are following the lead of PETRA by installing minibeta insertions. We hope to achieve an increase in luminosity by a factor of 2.5 to 3, working at a β_v^* value of about 4 cm. This is being accomplished by moving the interaction region quadrupoles closer to the interaction point and driving the quadrupoles to higher field.

In order to make room for the quadrupoles it was necessary to remove the compensating solenoids which are required for operating with the solenoid of the CLEO detector. Now, in order to provide compensation, we use three pairs of rotated quadrupoles appropriately arranged. Two pairs of these are located in the interaction region and one is further away in the lattice as shown in Fig. 1.

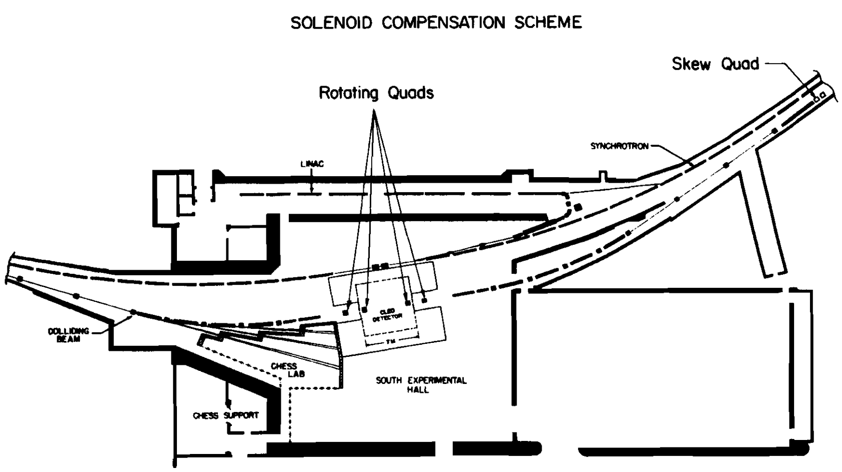

Fig. 1. The locations of the three pairs of rotated quadrupoles to compensate for the CLEO solenoid are shown. The quadrupoles nearest the interaction region are the normal interaction quadrupoles modified to permit physical rotation through five degrees. The outer quadrupole pair are normal skew quadrupoles.

Because of the tightness of space, instead of providing independent 45° quadrupoles we are actually providing the interaction quads with the means to physically rotate them through angles up to 5°. Thus we have installed the world's first really rotating quadrupoles.

As a further improvement for the CESR facility we are planning to install a high current gun in the linac, generally following the development work of SLAC. The anticipated increase in positron production rate will make it possible to eliminate the necessity to use the bunch coalescence scheme for positrons. This will provide much greater flexibility of operation and permit us to operate in the "topping off" mode. The change will save much of the time required for filling. This improvement is planned for the fall of 1982.

During the long shutdown of this summer we are also installing our superconducting coil in the large magnetic detector CLEO. The installation of the coil will save about $500,000 per year in power and will permit us to operate at 10 kG in the magnet as contrasted with operation at 4 kG with the conventional aluminum solenoid. This should significantly improve the momentum resolution of CLEO. During our present shutdown we are also installing four more octants equipped to measure ionization density, dE/dx, completing the set of 8 dE/dx octants. This should substantially improve our particle identification capability.

To further improve our particle identification we are currently building new electronics for the CLEO drift chamber to provide for dE/dx measurements inside the solenoid, together with charge sharing measurements on the wires for more precise z determination. We expect these new components to be installed before September, 1982.

Turning now to our longer range program I would like to discuss our plans for CESR II, a 50 x 50 GeV e^+e^- storage ring. This machine is designed to provide a first-class colliding facility for the study of the Z^0 resonance at moderate cost. It would have high luminosity at each of four interaction points to serve a significant fraction of the high energy physics community.

To minimize accelerator costs we plan to use superconducting R.F. accelerator cavities. Using a cost optimization calculation we estimate that a factor of two can be saved by using superconducting instead of conventional copper cavities. Most of this cost reduction comes from making use of the higher accelerating fields that can be obtained in conventional cavities and the elimination of power loss in the cavity walls.

We further intend to save in cost by holding firmly to an austere design--that is, one which is directed at the particular goal of providing good luminosity at the Z^0 energy but which does not provide for excessively high currents or energies greatly in excess of the requirement to reach the energy of the Z^0.

The principal characteristics of the facility we propose are listed in Table I. The peak design energy is 50 x 50 GeV with a luminosity at that energy of 3 x 10^{31} cm^{-2} sec^{-1}. In view of the success of the minibeta insertions we are now looking at options which might provide an increase of luminosity up to 10^{32} cm^{-2} sec^{-1}. These estimates are based on a conservative tune shift value of 0.03. A total of four working interaction regions are provided. For the normal beta values, we plan interaction lengths of only ± 2 or ± 4 meters in order to obtain high luminosity at small current. If minibeta sections are used, still shorter free space will be required, perhaps requiring the use of superconducting quadrupoles reentrant in the detector itself. The total power consumption for the facility will be about 25 M.W. Of this 17 M.W. will go into supplying R.F. power, 2.5 M.W. for refrigeration and the remainder for general utilities.

Because the whole design is based on superconducting accelerating cavities, it is important to describe our progress in this area. As long ago as 1975 we installed and operated a superconducting cavity in the 12 GeV synchrotron for a period of 9 months. That cavity operated at the S-band frequency at the level of 4 MV/meter and was of the "muffin tin" design, that is, it had the semblance of two rows of muffin tin cups facing each other along the beam line. Shortly after this success we greatly attenuated our efforts in this direction in order to put full efforts into the construction of CESR I. Now that CESR I is operating, we

TABLE I

BASIC PARAMETERS

Nominal Top Energy per Beam	50 GeV
Number of Interaction Points	4
Free Space for Experiments	4 and 6 m, 2 each
Luminosity at 50 GeV	3×10^{31} cm^{-2} sec^{-1}
Tune Shift	0.03
Beam Current per Beam	3.7 mA
Circumference	5.5 km
Bending Radius	500 m
R.F. Frequency	1.5 GHz
Energy Loss per Turn	1.1 GV
R.F. Voltage per Turn	1.5 GV
Cavity Gradient	3.0 MV/m
Length of Superconducting R.F. Structure	500 m
Total R.F. Power	10 MW
Total Power for the Facility	25 MW

have again increased our efforts to develop superconducting cavities with their use for CESR II in mind. Our present level of activity is about 2 million dollars per year, including the equivalent full-time efforts of about 6 physicists. We have chosen the frequency of 1500 MHz for our cavities, and have been making prototypes of the muffin tin variety.

Though we feel that we have a very good hold on the technique of producing standard cavities at fields exceeding 3 MeV/meter, our design requirement, there are a number of problems unique to storage rings which must be resolved. These are problems associated with high order mode excitation and questions of beam dynamics.

The circulating electron and positron bunches induce higher harmonic excitations in the cavity which can provide serious interactions with the beam and also deposit more than a megawatt of power in the liquid He cooled cavities. In order to avoid this problem, the induced energy must be piped away from the cavity and deposited in a load at room temperature. The cavity oscillations induced by a particular beam bunch must also be damped sufficiently rapidly so that they do not interact with the bunches which follow behind. In order to accomplish this, wave guides are coupled to the cavity through slots in particular individual cells to intercept the higher modes and the energy is conducted to a room temperature energy sink.

In addition to these problems there are also the field limitations due to the phenomena of multipactoring. We have found that grooving of the interior walls of the cells can greatly relieve this electron cascade problem. Recently in a two cell, full scale grooved cavity we were able to obtain a Q value of 1.8×10^9 at a gradient of 8 MV/meter. The design gradient for CESR II is only 3 MV/meter.

Shown in Fig. 2 is the first complete prototype of a five cell niobium cavity with higher order mode coupling wave guides which is currently being tested. We are currently constructing a 10 cell unit, complete with cryostat to insert in CESR for realistic beam tests in November of this year, 1981. During the fall and winter we plan to build a 5 meter production prototype unit. A total of 500 M of cavity operating at 3 MV/meter are required for the full CESR II design.

In May, 1980, we prepared a design study for CESR II.[1] This study was updated this spring.[2] For the recent document we made an architectural-engineering study of various sites. We have now chosen a site and have prepared an updated cost estimate for the project. In Fig. 3 we see the layout of the project, showing the ring, the interaction areas, the location of the R.F. accelerating cavities, and the main laboratory building. The site is located adjacent to the Tompkins County Airport, about 3 miles away from the present CESR laboratory. The total cost for the project is now estimated at $200 million in 1981 dollars.

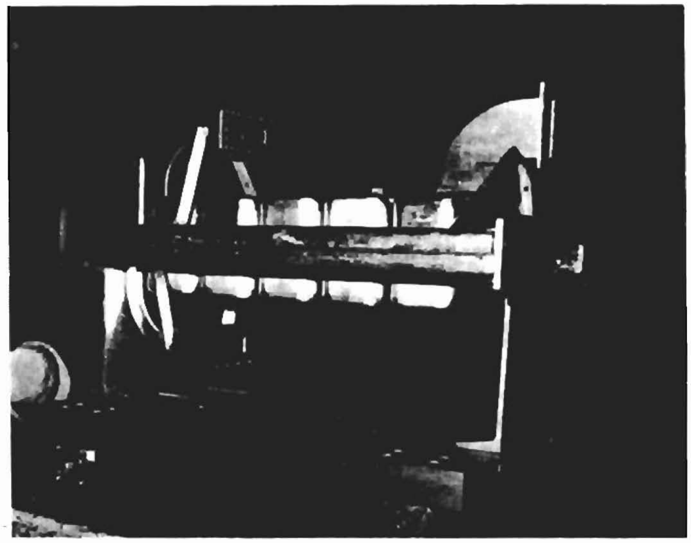

Fig. 2. A five cell, full scale prototype of the niobium superconducting cavity which operates at 1,500 MHz. The fundamental power coupling is at left below. The two upper wave guides couple to the transverse and longitudinal components of the induced higher order modes in order to conduct the energy away to room temperature sinks.

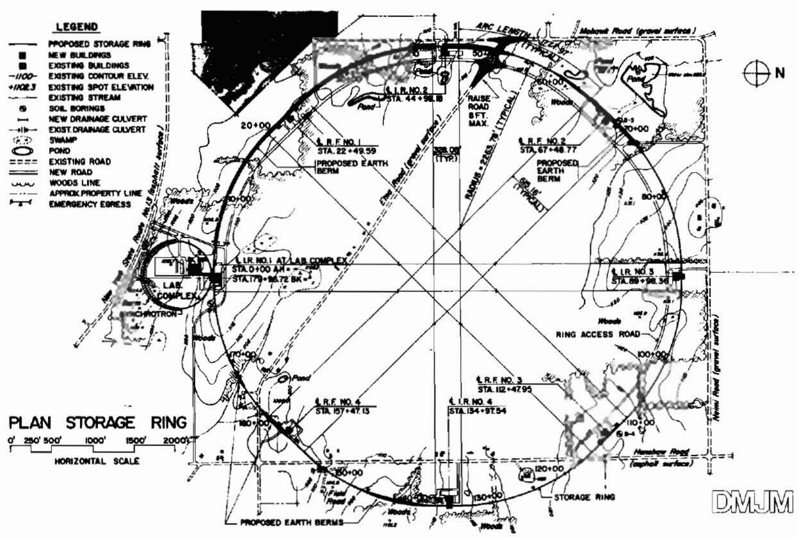

Fig. 3. Plan view of CESR II, 50 x 50 GeV, e^+-e^- storage ring. Eight arcs are separated alternately by four interaction regions and four R.F. stations. The central laboratory complex is shown at left, together with the injector ring. In the upper left is shown the end of a runway of the Tompkins County Airport.

During the last year we have conducted several workshop sessions including an experimental workshop to study the design of experimental equipment for the collider, a Z^0 theoretical workshop, an accelerator workshop to look at some of the single beam problems of large storage rings, and a cryogenic design workshop. Reports on these activities are given in appendices I, II, III and IV of Reference 2. We have found that within the high energy physics community there is a broad support and a high degree of interest in the proposed facility.

The 1980 design study was reviewed by the High Energy Physics Advisory Panel of the Department of Energy which met at Woods Hole, MA, last year. The committee recommended continued support of the R.F. superconductivity program with the expression of intent to have another review in 1981 or 1982. We hope to obtain the support of such a panel in making our proposal submission next spring.

The most optimistic time scale which is achievable presumes construction funding beginning in October, 1983, and extending for 3 years. On this schedule, operations will begin in October, 1986.

References:

(1) Design Proposal for a High Energy, High Luminosity Electron-Positron Collider Based on Superconducting R.F. Cavities. CLNS 80/456, May 1980. Newman Laboratory of Nuclear Studies, Cornell University, Ithaca, NY, 14853.

(2) Progress Report on a Design and Development Study for CESR II, a High Energy, High Luminosity Electron Positron Collider Based on Superconducting R.F. Cavities. CLNS 81/492. May 1981, with Appendices. Newman Laboratory of Nuclear Studies, Cornell University, Ithaca, NY, 14853.

Footnote:

[1] This work has been supported in part by the National Science Foundation.