Abstract

After completing collection of a substantial data set on the Ψ(4S) resonance, we hope to expand CESR running to cover the c.m. energy range from 3.1 to 11.2 GeV. In addition to an R&D program in specific technical areas, work is proceeding on a new type of synchrotron radiation source. In particle physics we foresee joining collaboration on an energy frontier machine within this decade.

1 CESR PHYSICS PROGRAM

CESR [1] operation above $10^{33}$ cm$^{-2}$-sec$^{-1}$ has provided a substantial data set for the CLEO collaboration on the Ψ(4S) resonance. The CLEO physicists are bringing 25 fb$^{-1}$ to conferences in summer, 2001.

In late June CESR will shut down for approximately 3 months to install superconducting quadruple magnets in the interaction region and complete the installation of a new synchrotron radiation facility (CHESS) beam line (“G-line”).

An approximately 8 month run on various Ψ resonances from 4.7 to 5.5 GeV beam energy will start in September. During this period machine performance in the 1.5 to 2.5 GeV beam energy range and beam dynamics associated with round beam operation will be evaluated in machine studies.

Charm physics running with CESR beam energies from 1.55 to 2.5 GeV might begin in early 2003 after a shutdown to install radiation enhancing wiggler magnets.

2 THE CESRc PROGRAM

The CESRc project will add superconducting wiggler magnets to the CESR ring, enabling effective operation from 1.5 through 5.6 GeV beam energy, giving access to charm and b thresholds using the same apparatus.

This program will provide definitive tests of new, percent level lattice QCD results and predictions of specific glue rich states of matter. In addition to having intrinsic merit for physics and providing support for ongoing b-physics measurements, the data will probe deeply the only well developed strongly coupled theory we have, QCD, a likely forerunner of the theories needed beyond the current energy frontier.

CLEO, with its good resolution and 94% hermeticity will be the most powerful detector ever used on this physics.

The 3 year run beginning in 2003 is projected to collect 6 million tagged D decays, 0.3 million Ds, and billions of J/Ψ decays, all nearly background free.

We have looked at many accelerator physics and engineering aspects of the low energy running. The primary issues are related to restoration of the radiation damping and horizontal emittance to levels comparable with 5.3 GeV running.

In a “natural” storage ring, the damping decreases proportional to the beam energy to 1/3 power, and the emittance in direct proportion to the beam energy. The scaling of several important parameters with the relativistic factor, $\gamma$, are:

- Damping time: $\tau \propto \gamma^{-3}$
- Synchrotron radiation power: $P_R \propto \gamma^4$
- Horizontal Emittance: $\varepsilon_X \propto \frac{\gamma^2}{Q_X}$
- Energy spread: $\frac{\sigma_E}{E_0} \propto \gamma$

The luminosity decreases with energy primarily for 3 reasons:

1) The electrons are “less stiff” and their trajectories are affected more by the space charge forces of the opposing beam.
2) The beam emittance decreases, increasing the space charge density for a given number of electrons, again increasing the space charge forces.
3) The decrease of damping reduces the “cooling” of the electrons heated by the beam-beam interaction.

CESR C will mitigate these effects by adding radiation via wiggler magnets. Some basic parameters for 1.885 GeV operation may be found in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Energy</td>
<td>1.885 GeV</td>
</tr>
<tr>
<td>Luminosity</td>
<td>$3 \times 10^{32}$ cm$^{-2}$-sec$^{-1}$</td>
</tr>
<tr>
<td>Current/beam</td>
<td>0.13 A</td>
</tr>
<tr>
<td>Bunches/beam</td>
<td>9 x 5</td>
</tr>
<tr>
<td>Beam-beam Param.</td>
<td>0.04</td>
</tr>
<tr>
<td>$\beta$ function at i.p. H/V</td>
<td>0.9/0.01 m</td>
</tr>
<tr>
<td>Trans. Damping Time</td>
<td>0.05 sec</td>
</tr>
<tr>
<td>Rel. Energy Spread</td>
<td>$0.8 \times 10^{-1}$</td>
</tr>
</tbody>
</table>

Table 1: CESR C Operating Parameters
2.2 Wiggler Technology

Some 18 m of wigglers at about 2T field are envisioned. This length will be achieved through installation of 14 small modular units having 5 cm beam aperture commensurate with the present CESR aperture. Most economical will be to place the wiggler units as close to the south as possible to limit the extent of the needed cryogenic infrastructure and to minimize the added boundary conditions on the ring optics. In order to limit further the total extent of the wiggler array, some rearrangements of the present dipoles will be made, affording further available space near the central lab facilities.

Achieving damping within ~2 times the 5.3 GeV values implies that 90% of the radiation in the ring will come from the wigglers. Second and third order nonlinearities in the wiggler fields become important and must be considered in wiggler and lattice design.

2.3 Other accelerator physics and engineering issues

In addition to the damping time, emittance and beam-beam limits mentioned above, there are further considerations necessary in assess in the feasibility of extending the energy range and estimating the achievable luminosities at the desired lower operating energies. Among them are: parasitic crossings; solenoid compensation; beam generated detector backgrounds; non-linearities in the existing optics and the additional non-linearities introduced by the wigglers; Touschek scattering; coulomb scattering on the residual gas; vacuum pumping; coupled bunch instabilities; bunch lengthening; injection and injector operation.

Each of these issues has been examined in considerable detail using well established calculational methods and simulations and the results used to estimate expected luminosities and luminosity lifetimes. The beam-beam parameter values (ξ=0.04) are conservatively chosen based on the appropriate damping decrement and achieved values measured at comparable machines world-wide.

Some of the accelerator physics issues mentioned have already been examined experimentally, namely the distributed ion vacuum pump performance at low magnetic field in the ring has been shown to be satisfactory and the performance of the injector at 1.5 GeV is good. Most of the others will be explored experimentally after installation of the new interaction region superconducting quadrupoles in summer of this year (2001).

Super conducting IR quadrupoles [2] will replace the permanent magnet IR quadrupoles during the summer of 2001, making optics for low energy operation realizable. The new quadrupoles provide the capability for β* of 3 cm in both planes for round beam optics.

CESR has operated with 4 super conducting RF cavities [3] since November, 1999. Two additional cavities have been planned for installation by the end of 2002. These will provide the added field gradient needed to shorten bunch lengths to 1 cm for compatibility with the planned 1 cm operating β*, with the S.C. IR quads. Furthermore, the additional cryogenic capability installed for the new cavities will have sufficient spare capacity for the wiggler modules.

2.4 Schedule

A prototype wiggler module will be completed by the end of 2001. By that time we will also have a manufacturing plan in place to produce the 16 wiggler units (including 2 spares) for CESR C operation. Operation at 1.885 GeV might begin in early 2003.

3 WORLD FACILITY COLLABORATION

For our future particle physics program the Cornell group is expecting to join an international collaboration in building and operating a linear collider via the Global Accelerator Network. We expect to be fully engaged in this new activity by mid decade.

4 ENERGY RECOVERY LINAC

Newman Laboratory will continue it’s on campus activities in providing synchrotron radiation for x-ray experiments. An exciting proposal for a 4th generation source incorporates an energy recovery linac to provide 100x the brilliance of 3rd generation sources and sub-picosecond timing. [4]

The state-of-art of photocathode electron sources makes a source with 2x10^-7 m-rad-MeV normalized emittance possible. Accelerating such a beam to 5-7 GeV without appreciable dilution would produce a source of unparalleled brilliance and timing capability. This can be done with a single pass linac-wiggler arrangement.

Without energy recovery the mains power required would approach 1 GWatt. However, by recirculating the beam through the high Q super conducting linac, the beam energy can be recovered and passed on to the newly accelerated beam.

A 2.5 cm period, 25 m long undulator with a 5 GeV, 100 mA beam would provide a brilliance of 10^{22} photons/sec/mm^2/mr^2/0.1%BW. Detailed design with optics have been worked out at Cornell and a proposal for a 100 mA, 100 MeV prototype facility is in preparation.
REFERENCES


