Design Status Report on the Collider Utility Straight Insertions

Brett Parker
Superconducting Super Collider Laboratory*
2550 Beckleymeade Ave., Dallas, TX 75237, USA

Abstract

The lattice for the rings of the Superconducting Super Collider is divided into arcs, a FODO array of superconducting quadrupoles and dipoles; interaction regions, places where the beams are focused and brought into collision within physics detectors; and utility sections, places where injection, acceleration, abort, halo-scraping, and other control and diagnostic functions are performed [1–3]. Recent modifications to the utility region design are reported here. Briefly these include lowering injection β-maxima by 40%; reducing the lengths and varieties of superconducting quadrupoles; improving conditions for injection matching; increasing abort admittance; mitigating component interferences; and identifying places for dampers and other beam instrumentation [4].

I. INTRODUCTION

The rings of the Superconducting Super Collider are divided geographically into east and west clusters and north and south arcs, as shown in Figure 1. The east and west clusters are in turn subdivided by function into optics modules, as shown in Figure 2. The design requirements for the interaction regions (IR) and hinge (HI) sections are discussed elsewhere. The utility sections that are described below include eight dispersion suppressor (DS) sections, four transition to interaction region (TI) sections, two transition to utility (TU) sections, and the east and west utility straight (EU and WU) sections. After reviewing the design of the TU, TI, and DS sections, we describe recent lattice changes associated with optimizing the design of the utility straight sections.

II. TRANSITION SECTIONS

The TU section, which provides a region of beam to separate the muon vectors from the IR and utility straight regions, is essentially a short (12 standard 90-m arc half cells) piece of arc with arc-like Twiss functions, as shown in Figure 3. Note that as with the arcs, a few dipole pairs are removed at π phase advance separation in order to provide contingency space for future technical systems.

The TI lattice (not shown) functions are very similar to those for the TU. The TI consists of a single cell in which

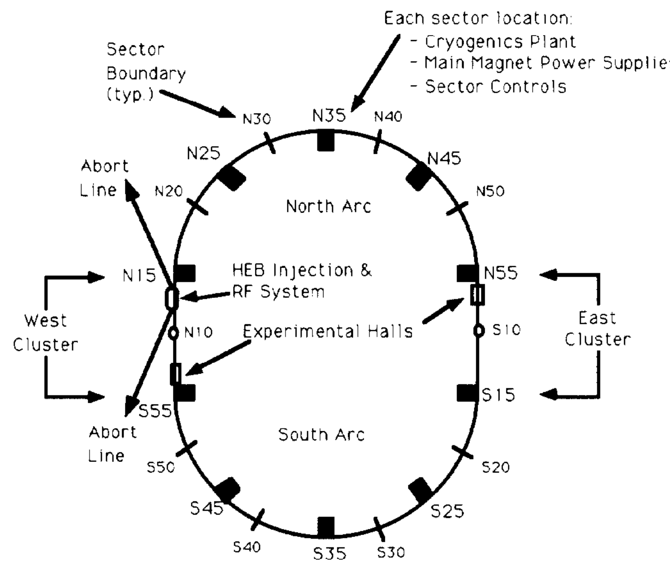

Figure 1. Layout schematic of Superconducting Super Collider.

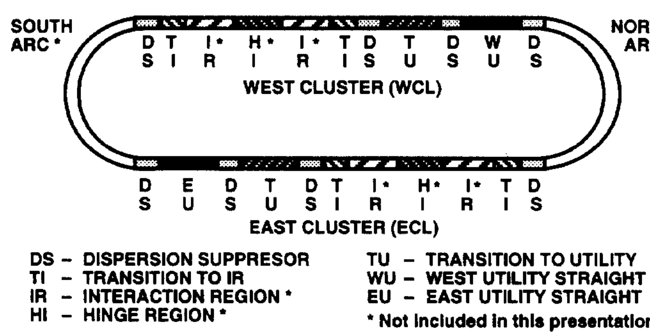

Figure 2. Section layout schematic.

*Operated by the Universities Research Association, Inc., for the U.S. Department of Energy under Contract No. DE-AC35-89ER40486.

The submitted manuscript has been authored by a contractor of the U.S. Government under Contract No. DE-AC35-89ER40486. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes.

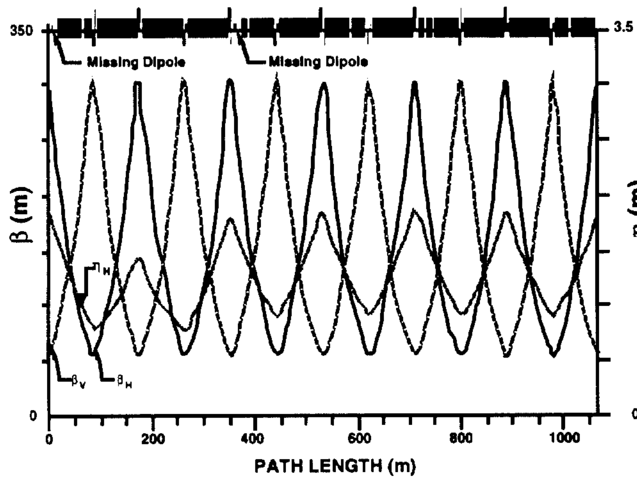

Figure 3. TU lattice functions.

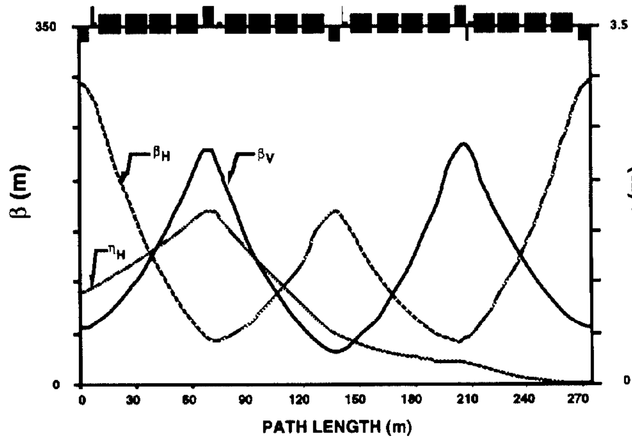

Figure 4. Dispersion suppressor lattice functions.

all bending is omitted; however the dispersion, $\eta \approx 0$ across the TI sections due to the neighboring DS sections. Each TI has skew quadrupole convector magnets at mid-half cell locations that are part of the global decoupling scheme. The TI sections are potential take-off and return points for a diamond bypass configuration.

III. DISPERSION SUPPRESSOR SECTIONS

The DS section, shown in Figure 4, is composed of cells with three-quarters the length and two-thirds the bending of an arc cell. This gives an $L \times \theta$ of half that of a standard arc cell, and enables matching from full to zero dispersion over the 270-m extent of the four DS half cells. There are DS sections surrounding the utility straight and IR sections (the HI performs as back-to-back DS sections) in order to kill the dispersion in these regions. It is anticipated that a controlled amount of dispersion will be introduced into the east utility straight in order to enable off-momentum scraping in the EU.

IV. UTILITY STRAIGHT SECTIONS

While the main superconducting quadrupole lattices are identical for the EU and WU utility straight sections, the two sections are quite different in nature due to the inclusion of extended warm regions in the WU for beam injection, acceleration and abort. The Twiss functions for the baseline (TOP-REV0) WU lattice are shown in Figure 5 for comparison to the current (TOP-REV1) lattice shown in Figure 6. The EU and WU straight in section are both equal in length to 15 standard 90 m half cells.

In the central warm bend region of the WU is a series of symmetric and asymmetric Lambertson-style magnets that provides a means for dispatching a collider ring fill to an external backstop by firing a series of abort kicker magnets. Note that the beam scraper system (i.e., high-intensity collimators) shares the same central dogleg with the abort system in order to point the neutral vector and

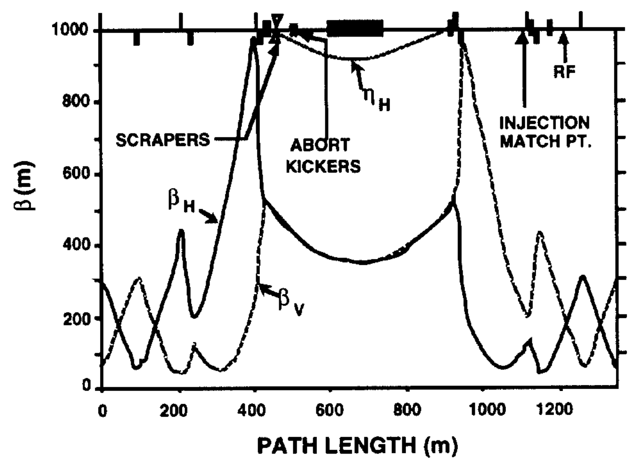

Figure 5. Baseline TOP_REV0 lattice functions for west utility.

secondary charged particles escaping from the scraper away from downstream superconducting magnet apertures.

One significant change involved moving the abort kickers upstream of the central quadrupole doublet, both to avoid the intense radiation field near the scrapers and to keep the abort kicker $\int B \cdot dl$ at a manageable level. To accomplish this the polarity of these quadrupole doublets on either side of the central dogleg was flipped. With the new polarity it is possible to reduce both the β-maximum and the lengths and number of distinct types of main superconducting quadrupole magnets as shown in Figure 6.

At the request of the IR design team, the utility straight transfer matrix was further constrained to have a unit map as this simplifies the scheme for IR chromaticity correction in the north and south arcs. Also we reduced by half the $\int B \cdot dl$ required for the injection kicker magnets by providing lattice space for these kickers near to $\pi/2$ phase advance from the injection Lambertson magnets. Favorable FODO-like lattice functions were maintained at the injection matching point.

The design and review process for the WU has been greatly facilitated through an ability we have developed

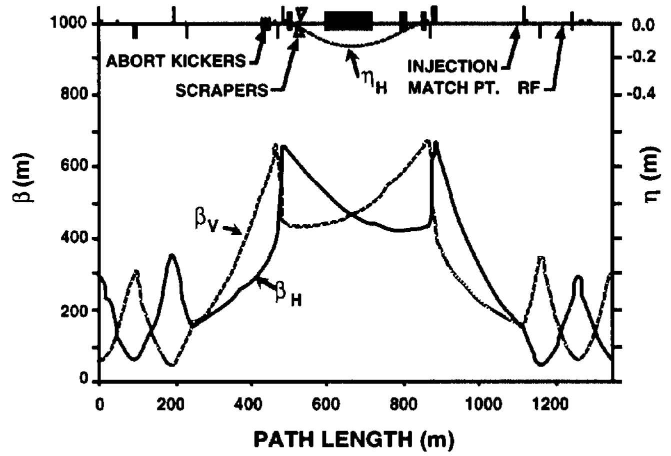

Figure 6. Current TOP_REV1 lattice functions for west utility.

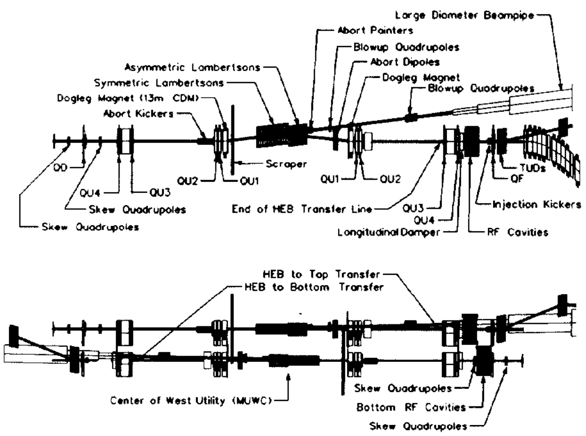

Figure 7. West utility layout.

to rapidly and automatically build a 3-dimensional CAD model of all major technical components and beamlines almost directly from the survey output of accelerator design programs (MAD, TRANSPORT, SYNCH, etc.). This facility, which allows one to "try out" a new lattice component configuration and to "see" points of interference, has been found critical in laying out and verifying abort and tune-up beamline components [5].

With the technical component layout in hand it is much easier to wrap tunnel across sections, underground galleries, and access shafts around the various beamlines and subsystems with considerable confidence [6]. For instance we have determined locations where a single shaft provides access to High Energy Booster (HEB) extraction kickers and an underground gallery housing Collider abort kicker power supplies. Design studies indicate that it should be possible to excavate the tunnels for the HEB-to-Collider beam transfer lines so as to provide sufficient cover to enable operation of the HEB while maintaining access to the Collider. Earlier concepts for this region, based upon opening up a large underground "cathedral" connecting the HEB and Collider rings, would have required the introduction of a prohibitive amount of mass shielding.

We are currently midway through the Title I phase for the WU underground tunnel design. It is anticipated that the data base driven nature of the CAD model will be important in future studies of construction, installation, operation and maintenance. The CAD model forms a complementary tool to the component data interface (CDI) in facilitating accelerator design work [7].

V. SUMMARY

In summary the TU, TI, and DS sections have undergone minor design tuning which involved reducing the number of different spool types and empty cryostat lengths. The EU and WU have undergone significant changes during the process of determining their detailed layout. We concluded that early 3D CAD modeling has proved invaluable to this effort. Continued modeling will be critical in future efforts, which include special magnet, component stand, cryogenic bypass, LCW, cable tray, and RF waveguide design and installation work.

VI. ACKNOWLEDGEMENTS

These results are the product of work from many people: Al Garren, David Johnson, and YunHai Cai for optical design fitting; Mike Syphers, Dave Ritson, Karl Brown, and Ron Schailey for many important discussions and suggestions; Dale Orth for putting together his macro/database solution for creating 3D CAD models; and, finally, Rainer Meinke and Lindsay Coffman for their continued support and encouragement.

VII. REFERENCES

[1] Site-Specific Conceptual Design of the Superconducting Super Collider, SSC Lab, December 1989.

[2] "Collider Accelerator Arc Sections Level 3B Element Specification," SSC Lab Document Control #E10-000027, August 1992.

[3] "Collider Accelerator Utility Sections Level 3B Element Specification," SSC Lab Document Control #E10-000073, Draft, January, 1993.

[4] "Collider Preliminary Design Requirements Review (PDRR): Copy of Presenters' Transparencies," SSC Lab, Available SSCL Library, January 1993.

[5] "Facility Modeling of West Utility Straight Tunnel Sections," SSCL-Preprint-339, M. Butalla, B. Parker, D. Orth, and A. Elioff, presented to IISSC, May 1993.

[6] "SSC NIS to N10 Basic Tunnel Design Requirements (Including West Utility Straight)," SSC Lab Document Control #Y16-00188.

[7] "Accelerator Design Using Databases and Graphical User Interfaces," SSCL-620, M. Popp, April 1993.