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Beam Loss Handling at the SSC

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Abstract

A scraper/collimation system is required to localize the beam loss in the Collider of the Superconducting Super Collider to a few predefined locations and by doing so to minimize the irradiation of superconducting magnets, to sustain favorable background conditions in the Interaction Regions (IR), and to reduce the impact of radiation on other equipment, personnel, and the environment. Results of full-scale simulation are presented for various systematic and accidental beam loss.

I. INTRODUCTION

A fraction of the beam lost in the Collider due to pp-collisions at interaction points, beam-gas scattering, beam halo scraping, various instabilities and errors will result in the irradiation of conventional and superconducting components of the machine [1]. Catastrophic effects of the accidental beam loss should be minimized with some special measures. A very reliable beam collimation system is required to protect accelerator equipment against irradiation, to sustain favorable background conditions in the IRs, and to reduce the impact of radiation on personnel and the environment.

Calculated beam loss rate due to beam-gas interaction is about 3×10^3 p/m/s at the baseline parameters. It is distributed almost uniformly along the Collider. Local sources such as pp-collisions and scrapers add some peaks to the above "pedestal". Results on beam loss distribution in this paper are presented for those peaks only.

II. SCRAPER SYSTEM

The first approach to the Collider beam scraper system is described in [2]. Primary features follow Tevatron [3], UNK [4] and LHC [5] schemes. A current betatron collimation system [6] is situated in the Collider west utility straight section and consists of horizontal and vertical scrapers and a set of collimators (Figure 1). Scrapers and collimators have movable jaws controlled by high-precision motors. The jaws are surrounded with radiation shielding. Tungsten targets, 1-mm thick, are used to deflect halo particles deeper into the scraper front face. The target-scraper offset is approximately 0.05 mm. The essential part of the beam collimation system is a horizontal dogleg structure, which provides a complete interception of neutral and low-energy charged particles out of the scrapers. The horizontal dogleg is created by two superconducting dipoles and a set of warm magnets including symmetric, asymmetric Lambertson, and resistive magnets. To provide a fine tuning of the beam on the scrapers existing in the utility straight, eight spool pieces are used. A high-precision feedback system will be used to control a scraping intensity.

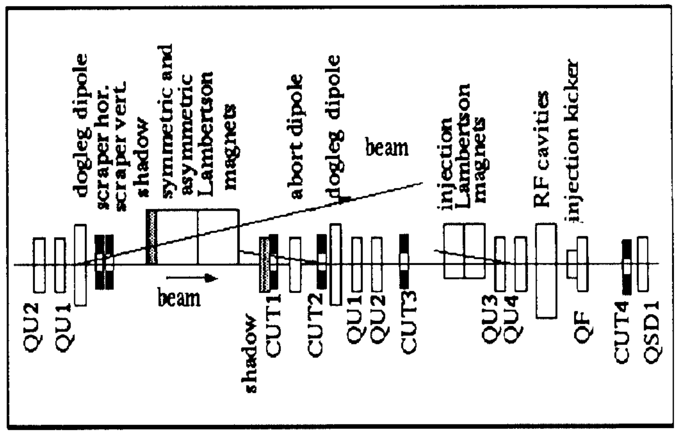

Figure 1. Scraper System in the West Utility.

The expected scraping rate is rather high [6]: about 1% of intensity at the very beginning of acceleration and then at flattop 3×10^9 p/s over the first 15 minutes and 4×10^8 p/s during the collisions (24 hours). The overall design of the jaws, cooling system and radiation shielding is not a trivial engineering problem. The west utility straight has near zero dispersion, so modifications to the east utility for off-momentum scraping are under consideration.

III. IR COLLIMATORS

A set of collimators is required in the Interaction Regions to protect the final focus triplet and vertical bending magnets. The current set for the East IRs consists of 14 collimators with movable jaws and 4 collimators of the fixed aperture. Optimal jaw position for the first group is 20 σ from the circulating beam axis. Each collimator includes a steel jaw 3 m long surrounded with radiation shielding.

The fixed aperture collimators (CIR01-04) are placed in the experimental halls just upstream from the low-β quadrupoles. They deal with relatively low energy sec-

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

0-7803-1203-1/93$03.00 © 1993 IEEE

ondaries produced at the interaction points (IP). Other collimators intercept high energy protons (mainly diffractive) produced in beam interactions all around the machine. Collimators CIR1 and CIR5 are used to intercept secondaries produced by beam-gas interactions. For each ring, one collimator (CIR1) is situated upstream IP and two more (CIR2, CIR3) – downstream IP, just down the common vertical bending magnets. Collimator CIR4 is placed in the middle of the hinge region at a nonzero dispersion point. Collimator jaw positions at injection and top energies are shown in the Table 1 and 2, respectively.

Table 1
Scraper and Collimator Jaw Positions at Injection.

	Beta hor.(m)	Beta ver.(m)	Position hor.(mm)	Position ver.(mm)
Scraper	611	430	−5.4	−4.5
CUT1	422	584	+7.1	+8.4
CUT2	423	621	−7.1	−8.7
CUT3	480	287	+7.5	
CIR1	316	142	−6.2	−4.1
CIR01	64	63	12.5	12.5
CIR02	64	65	12.5	12.5
CIR2	178	462	−4.6	−7.5
CIR3	140	222		−5.2
CIR4	103	185	−3.5	
CIR5	318	141	−6.2	−4.1
CIR03	63	65	12.5	12.5
CIR04	65	65	12.5	12.5
CIR6	177	476	+4.6	+7.5
CIR7	138	230		+5.2

Table 2
Scraper and Collimator Jaw Positions at Top Energy.

	Beta hor.(m)	Beta ver.(m)	Position hor.(mm)	Position ver.(mm)
Scraper	611	430	−1.7	−1.4
CUT1	422	584	+2.8	+3.3
CUT2	423	621	−2.8	−3.4
CUT3	480	287	+3.0	
CIR1	4108	1554	−8.9	−5.5
CIR01	799	791	12.5	12.5
CIR02	791	799	12.5	12.5
CIR2	2457	6389	−6.7	−11.0
CIR3	1007	2605		−7.0
CIR4	103	174	−1.4	
CIR5	4097	1591	−8.9	−5.5
CIR03	796	812	12.5	12.5
CIR04	812	796	12.5	12.5
CIR6	2448	6554	+6.7	+11.0
CIR7	1001	2675		+7.0

IV. BEAM LOSS DISTRIBUTION

With no movable collimators in the IRs a maximum beam loss rate in superconducting magnets due to only

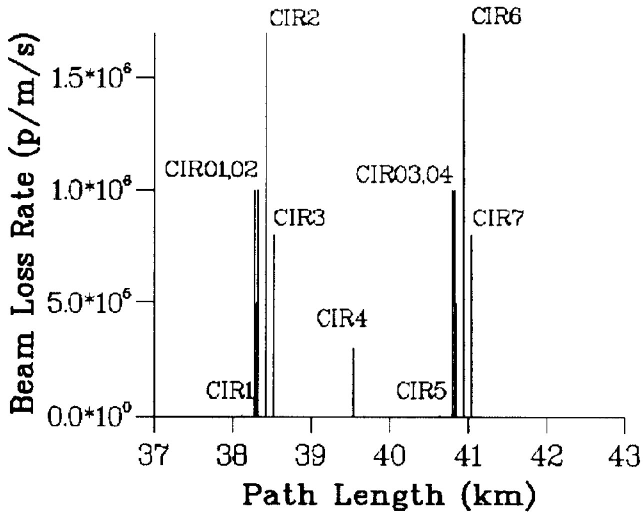

Figure 2. Beam Loss in IRs at Collisions (Collimators are ON).

pp-collisions is a few times 10^5 p/m/s. Being added to other sources this exceeds any possible limits [1, 6]. With the collimators at 20 σ calculated beam loss distribution in the IRs is shown in Figure 2. Beam loss rate is decreased down to $(4-8) \times 10^3$ p/m/s at all the IR superconducting magnets. Most of loss is intercepted by CIR2 and CIR6 collimators.

It turns out that the IR collimators can't protect completely the beta-peak region against protons outscattered of the scrapers. Beam loss distributions due to that component calculated with and without collimators are shown in Figure 3 and 4, respectively. Even with the collimators on, beam loss rate in QL3 quads is unacceptably high. The solution is three additional collimators in the West Utility downstream of the abort Lambertson's magnets. They provide good interception of most of the scraper protons.

V. ACCIDENTAL BEAM LOSS

The unsynchronized injection and abort system kicker misfire/prefire result in the additional beam loss in the Collider components. The above collimation system is intended to protect superconducting magnets in those cases also, if the injection timing error is shorter than 0.7 μs. For the larger errors, the injected beam is lost in a few superconducting magnets causing the catastrophic consequences.

In case of injection kicker misfire, the beam must be aborted from the Collider within one or two turns, because the transverse damping system is not designed to damp injection beam displacement in this case to an acceptable level. The IR collimators are used to protect superconducting magnets in this case.

The abort kicker prefire results in coherent betatron oscillation of the beam with rather high amplitude. Collimator CIR5 is used to protect the low-β quads against ir-

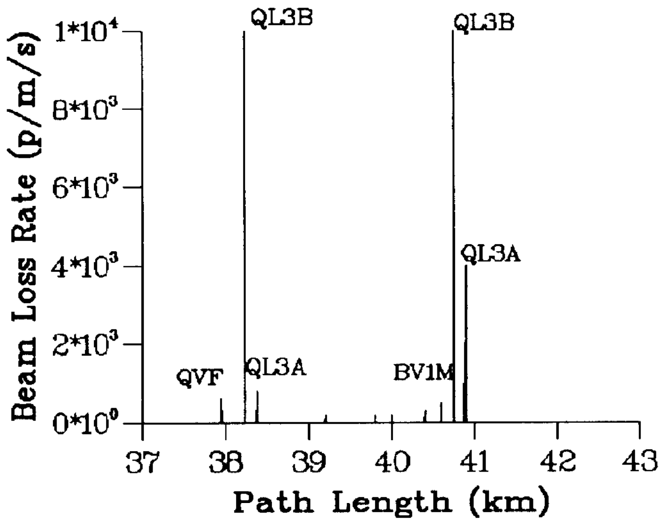

Figure 3. Beam loss in IRs at Scraping (Collimators are OFF.)

radiation in this event. Without that collimator the beam loss rate in the final focus triplet is 50 to 100 times higher of the quench level.

VI. CONCLUSIONS

The designed measures should provide the reliable protection of superconducting components against excessive irradiation.

VII. REFERENCES

[1] I.S. Baishev, A.I. Drozhdin, and N.V. Mokhov, SSCL-306 (1990).

[2] M. Maslov, N. Mokhov, and I. Yazynin, SSCL-484 (1991).

[3] A.I. Drozhdin, M. Harrison, and N.V. Mokhov, Fermilab FN-418 (1985).

[4] I.S. Baishev, V.N. Chepegin, A.I. Drozhdin et al.,*Proc. of the 14th Int. Conference on High Energy Accel.*, Japan (1989), part III, p.667.

[5] L. Burnod, J.B. Jeanneret, CERN SL/91-39 (EA), Geneva (1991).

[6] N.V.Mokhov, Collider Utility Sections PDRR, SSCL, January 1993.

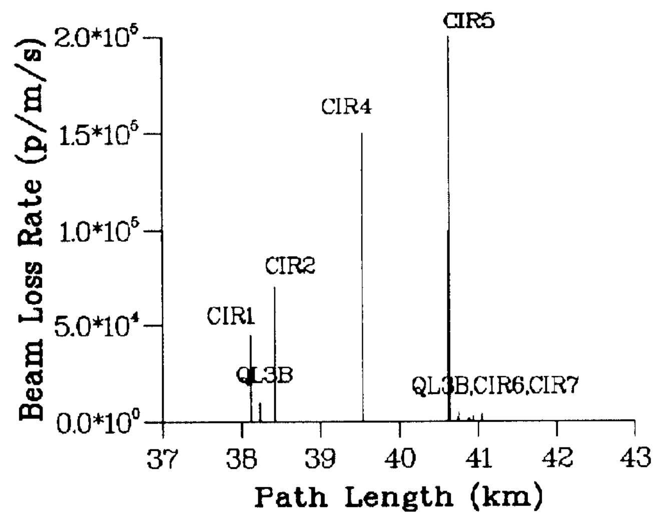

Figure 4. Beam loss in IRs at Scraping (Collimators are ON).