SLAC–PUB–5774
March 1992
(A)

RESULTS OF IR WORKING GROUP*

D. Ritson
Stanford Linear Accelerator Center
Stanford University, Stanford, California 94309
and
Superconducting Super Collider Laboratory
Dallas, Texas 75237

ABSTRACT

The IP luminosity at the Eloisatron will direct very large fluxes of hadronic debris into the IR quads. For instance at 1.10^{35} cm^2/sec the flux corresponds to 180 kilowatts. Already at the SSC fluxes in the neighborhood of 2 kilowatts are expected to require special handling. Scaling from SSC design experience we propose a configuration for the first IR quads at the Eloisatron capable of handling the heat load and radiation problems.

Introduction

The best super magnet design at the SSC is estimated to handle ∼200 Watts into a 15 m magnet and a maximum integrated dose of 1,000–5,000 Mrad.

The acceptable chromaticity from an IR is in the neighborhood of 100 units for present SSC chromaticity correction schemes. We assume that this will be unchanged at the Eloisatron. If correction schemes local to the IR are used this may underestimate acceptable chromaticities by a factor of two or so.

The required quadrupole aperture should be sufficient to accommodate beams separated by 10-15 σ. Allowing for a beam stay clear of $\sim 5\sigma$ a good field region of the order of $20 - 25\sigma$ is required. Typically actual quad bores needed are 2-3 times greater than the good field region and therefore at the Eloisatron IR quad bores should correspond to this or $\sim 40 - 50\sigma$.

Subject to these constraints the IR should be configured to maximize the luminosity at a fixed current corresponding to the β^*_{IP} being minimized. We design below for a target luminosity of $\sim 10^{35}$ cm^2 /sec by scaling from SSC design configurations.

Contributed to the INFN Eloisatron Project: 19th Workshop:
Maximizing Luminosity of Hadron Colliders at 100 TeV
Erice, Italy, November 13–19, 1991

* Work supported by Department of Energy contract DE–AC03–76SF00515.

SSC Designs

At 20 TeV and a nominal luminosity of 10^{33} cm^2 /sec there would be 320 watts of hadronic debris directed towards the IR quads a figure substantially less than the Eloisatron goal of 180 kilowatts.

We quote from design studies of Mokov et al for a standard IR triplet of 4 cm bore (design A) and a design B with the first member of the triplet being a 1 cm warm bore magnet followed by 6 cm bore quads with a 1 cm thick copper liner.

The triplet is split into a first lens Q1 and a second lens of two parts Q2 and Q3 and a third lens Q4. Each of the lens is approximately 12 m long and the face of Q1 is 20 metres from the IP. Mokov et al estimate that for design A the watts into Q1, Q2, Q3 and Q4 would be 50,15,26 and 15 respectively. The corresponding peak dosage is 320,192,220 and 96 Mrad/yr.

For design B the radiation and heat load for the warm bore Q1, is no problem and the watts into Q2,Q3 and Q4 are 3.4, 13.9, 2.1 with corresponding Mrads/yr of 20,84 and 12.

Scaled to the Eloisatron design A would miss by $\sim$ 100 and design B would miss by a factor $\sim$ 25.

Eloisatron Designs

If quad bores are unchanged one can map an existing design by scaling all longitudinal lengths by the square root of the energy E. If the quad bore A is also changed (without changing the pole tip magnetic field) the scale factor S is $\sqrt{EA}$. This scaling results from the interplay of weaker gradients and longer quad lengths. To maintain constant chromaticity requires β^*_{IP} to scale as S. Then β_{max} in the IR quads scales $\propto S$. The maximum acceptable emittance ϵ_{max} scales as

$$\epsilon_{max} \propto \frac{A^2}{S^2 \beta_{max}}$$

or as

$$\epsilon_{max} \propto \frac{A^{1/2}}{E^{3/2}}$$

We consider first a low luminosity design where the constraints are simply lattice optics. Secondly we consider a full luminosity design that involves further compromises required to handle the heat and radiation loads.

Low Luminosity IRs (Only Lattice Constraints)

Leaving the quad bores unchanged and scaling by $\sqrt{E}$ the β^*_{IP} will be increased from 0.5 m at the SSC to 1.2 m at the Eloisatron, the β_{max} will go from 10 km to 22 km and the acceptable normalized emittance would be $\sim 1.4.10^{-6}$ m rad.

Full Luminosity IRs Designed to Accommodate Heat and Radiation Loads

To handle full luminosity we required a long region after the detector and prior to the first IR quad consisting of warm bore sweep field to remove and absorb the radiation from the IPs prior to the first quad. This region could either utilize dipole dogleg (a natural achromat) or straight dipole fields to provide separation and minimize the effects of long range beam beam interactions.

To achieve a satisfactory solution we tried successively larger scale up factors with associated larger bore magnets until we estimated the quads could safely absorb the radiation and heat loads.

From the previous discussion a simple $\sqrt{E}$ scale cannot handle radiation and heat loads. With a scale factor increased to three the rear quads still come too close to the beam-line and would be unlikely to meet the heat and radiation load requirements.

For a scale factor of four the bore of the rear quads becomes 12 cm and appears to lie outside the main cone of hadronic debris from the IP. This we believe could provide a feasible configuration for the IR quads.

Under these conditions the β^*_{IP} is increased to 2 m, the β_{max} to $\sim$ 40 km and the maximum normalized emittance would be $\sim 2.10^{-6}$.

Table 1 lists the required IP configuration corresponding to the above for a 100 TeV Eloisatron. Fig. 1 shows the associated beta values as a function of distance away from the IP.

The above are of at best only estimates. However in view of the speculative nature of the Eloisatron they are probably quite adequate at this point of time.

Conclusions

We believe that even for fluxes of hadronic debris of 180 kilowatts into the IR quads that an adequate IR design is still possible. Our proposed design requires a quad configuration twice as long as that dictated solely by considerations of lattice optics. This permits the use of lower quad gradients and larger quad bores. The larger quad bores and a long region of warm bore magnetic fields in the long drift from IP to IR quads should provide tolerable heat and radiation loads to the IR quads.

Thus heat and radiation load considerations will increase minimum achievable β^*_{IP}s and hence lower peak luminosities by a factor two relative to estimates derived solely from lattice optics.

Eloisatron IR Quad Configuration			
Type		Length (M)	Field at 6 cm (T)
	IP		
DRFT		20.00000	
DRFT		90.00000	
QUAD		52.87838	−4.0
DRFT		1.00000	
QUAD		46.65438	4.0
DRFT		1.00000	
QUAD		46.65438	4.0
DRFT		1.00000	
QUAD		52.87838	4.0
DRFT		1000.00000	
	FOCUS		

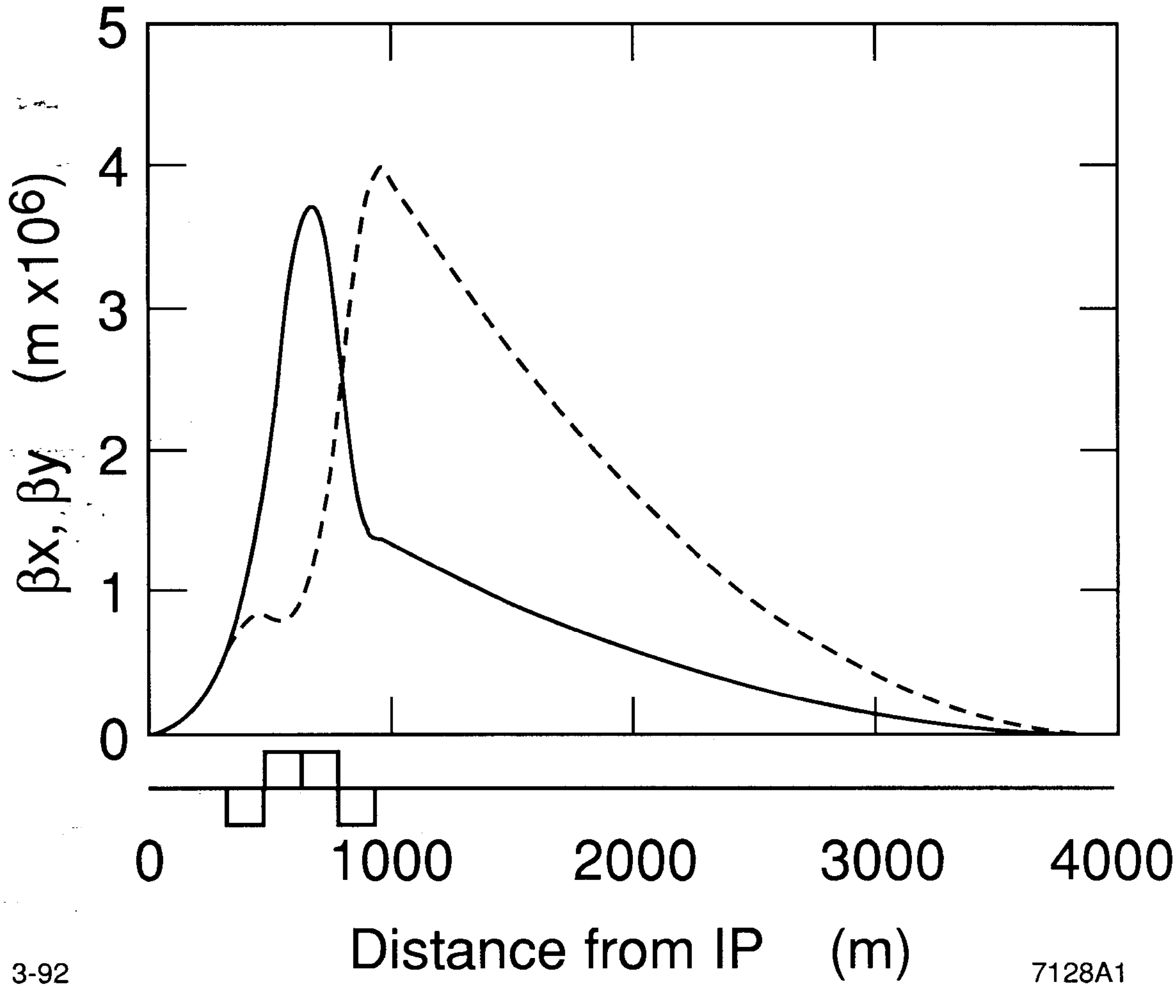
5
4
3
2
1
0
βx, βy (m x10^6)
0
1000
2000
3000
4000
Distance from IP (m)
3-92
7128A1

Fig. 1