Fermilab

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Field- and Energy-Independent Normalization of SSC Collider Ring Costs

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The SSC Collider Ring represents the dominating cost element of the SSC project. The number of variables involved in optimizing the facility is very large, so it is helpful to parameterize them in a way that allows a straight forward comparison of primary options.

The scale of the ring is set by the dipole bending field relationship.

$$R(\text{km}) = \frac{10}{3}\frac{E(\text{TeV})}{B(\text{tesla})}$$

In a real synchrotron the dipole field is not continuous, but is interrupted by drift spaces and long straight sections. This results in an effective radius for the machine that is greater than the simple dipole radius. For the Reference Design Study the circumference of the Collider Ring at 20 TeV and 5 tesla is 113km. Assuming that this field dilution is typical for colliders, the average bend field relation becomes:

(1) $$\boxed{R_{CR}(\text{km}) = 4.5\ E(\text{TeV})/B(\text{tesla})}$$

To compare different systems, it is useful to work in terms of a unit angle, rather than a radius, since a full circle is required for the Collider. Substituting $d\theta = dl/R$ into (1)

(2) $$\boxed{d\theta = \text{const.}\ \frac{B \cdot dl}{E}}$$

For simplicity unit angle is defined to be 1 foot for 5 tesla. For 20 TeV the multiplier for a full ring is then 3.71×10^5, the circumferance of the Collider in feet at 20 TeV and 5 tesla, times the cost/unit B • dl. The multiplier scales with energy.

Table I lists the relative length factors for constant B·dl, normalized to 5 tesla, and the resultant costs per unit B · dl for various systems. The total cost fora collider ring is derived by multiplying the appropriate cost per unit B · dl by the full ring multiplier for that energy and adding the fixed costs from Section 3 of Table I.

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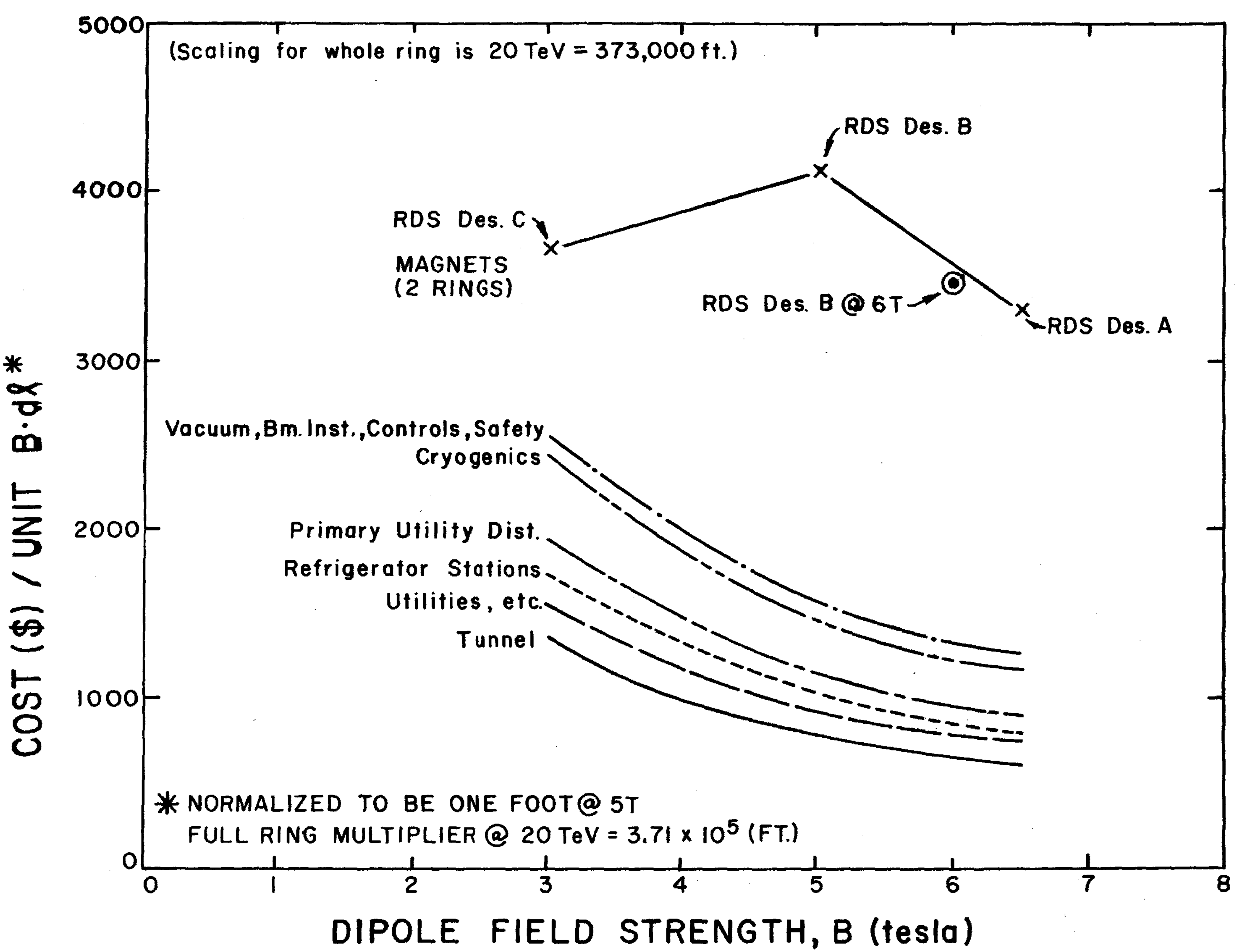
Figure 1.
SSC: Collider Ring Normalized Unit Costs



INCREMENTAL COST/UNIT B·dℓ FOR COLLIDING RING SYSTEM WITH 2 MAGNET RINGS

TABLE I

SSC COSTS PER UNIT ANGLE
SSC COLLIDER RING: P-P
UNIT COSTS NORMALIZED TO 5 TESLA[0]

1. Parameters					
i. Dipole Field Strength	3	4	5	6	6.5
ii. Relative length (B · dl=constant)	1.67	1.25	1	.83	.77
2. Costs/Unit B · dl					
a. Conventional Facilities					
i. Tunnel (9' 0 with notches)[1]	$1323	993	794	662	611
ii. Tunnel Utilities, Vent, Drainage[2]	242	181	145	121	112
iii. Refrigerator Stations*	148	148	74	74	74
iv. Primary Utility Distribution[2]	215	161	129	108	99
Subtotal, Conventional	$1928	1483	1142	965	896
b. Technical					
i. Magnets (including end boxes, etc.)	$1101[4]		2562[4]		2028
ii. Cryogenics	488	389	311	280**	280
iii. Vacuum, Beam Inst., Controls, Safety System	135[5]	126	117[6]	98	99[7]
Subtotal, Technical	$1724		2990		2407
TOTALS	$3652		$4132		$3303

3. Fixed Costs	
a. Conventional Facilities	
i. Injection Tunnels (2) 8' Ø	$13.12M
ii. Experimental Areas (4)[3]	64.8 M
Subtotal, Conventional	$77.9 M
b. Technical	
i. Main Power Supply & Corr. P.S.	$34.4 M
ii. RF, Injection, Abort	18.6 M
Subtotal, Technical	$53.0 M
TOTAL FIXED	$131.0 M

[0] For scaling, 20 TeV is 113 km (371,000 feet).

[1] Harza Engineering Study. [2] Reference Designs Study.

[3] Underground enclosures from Harza. Grade level structures from RDS.

[4] RDS, Table 8.2-1. [5] RDS, Table 7.3-5. [6] RDS, Table 6.3-5.

[7] RDS Table 5.3-6. *Normalization is 2 for 3T, 4T, 1 for all others.

**Assume onset of cryoload from synchrotron radiation.