



Brookhaven
National Laboratory

BNL-105785-2014-TECH

EP&S No. 72;BNL-105785-2014-IR

Optics of Beam #B5

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September 1974

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

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BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

EP&S DIVISION TECHNICAL NOTE

No. 72

D.G. Ryan

September 9, 1974

OPTICS OF BEAM #B5

Introduction

Three beams now share the B target station; MESB, B1, and B5. It will be assumed that a tight focus must always be maintained at B for proper operation of the MESB. The remaining beams, B1 and B5, share common elements in such a way that B5 cannot be operated unless B1 is set to negative polarity above a momentum of ~ 8 GeV/c.

B1 - B5 Sharing

1. Settings - The settings of the exclusive optical elements of beam #B5 have been recalculated due to the downstream movement of the B' target station by 15 inches. Table I lists the currents, shunt readings, and computer counts for the three compatible running conditions of B1; 8, 12, and 20 GeV/c negative polarity (note that 100 mv shunt reading \equiv 4000 computer counts).

2. Transmission - Figures 1 - 3 show ray traces for the above mentioned running conditions. The rays plotted are ± 1 mr horizontally, ± 1 mr vertically, and $\pm 1\% \Delta p/p$. Limiting apertures of ± 1.375 in.

horizontally in Q7 and ± 0.75 in. vertically at the downstream end of the wall have been used to calculate the acceptances listed in Table II.

As there are no direct measurements of the proton beam divergence at the B target, we have done a reverse ray trace from the target to an upstream flag and this is shown in Figure 4. The beam size as measured by the flag is consistent with divergences of ± 2 mr horizontally and ± 5 mr vertically at the B target. Using these figures, the transmissions from B to B' have been calculated and are given in Table II. Also

given in Table II are the transmissions with a 2-in. tungsten target. This attenuates the proton beam by 50%, and introduces 2 mr of multiple scattering.

B5 Exclusively

1. Settings - Maximum transmission from B to B' is achieved when B5 has control of all the common transport elements. The calculated settings for this case are given in Table III. Magnet D1 must have a 2% ramp to compensate for the change in beam momentum. If no ramp is installed, the settings are the same except that the polarities of Q6 and Q7 should be reversed.
2. Transmission - Figure 5 shows a ray trace for the case where magnet D1 is ramped. The rays plotted are ± 2 mr horizontally, ± 5 mr vertically, and 1% $\Delta p/p$. The limiting apertures are ± 1.375 in. horizontally in Q6, and ± 0.75 in. vertically in the wall. Acceptances and transmissions both for this case and for when D1 is not ramped are given in Table II.

Conclusion

Optimum transmission to the B' target station is achieved when B5 has exclusive control of all magnets between B and B'. Compatible running of B5 and B1 is possible when B1 is set to negative polarity and the intensity requirement at the B' target station is $\sim 2 \times 10^{10}$ protons per pulse.

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TABLE I
 B1 Compatible Settings of B5

B1 Momentum (GeV/c Negative Polarity)	Magnet	Polarity	Current (amps)	Shunt (mv)	Computer (counts)
20	D3	A	2154	53.85	2154
	D4	B	240	30.00	1200
	Q6	B	1551	51.70	2068
	Q7	A	2157	71.90	2876
	P1 D5	as required B	as required 2750	68.75	2750
12	D3	B	836	20.90	836
	D4	A	91	11.40	455
	Q6	B	1663	55.43	2217
	Q7	A	2273	75.77	3031
	P1 D5	as required B	as required 2750	68.75	2750
8	D3	B	2347	58.68	2347
	D4	A	261	32.60	1305
	Q6	B	1683	56.10	2244
	Q7	A	2291	76.37	3055
	P1 D5	as required B	as required 2750	68.75	2750

TABLE II

Transmission to B' Target

B1 Momentum (GeV/c)	8	12	20	B5 Only (D1 ramped)	B5 Only (No ramp)
Acceptance ($m_r H \times m_r V$)	$\pm 0.60 \times \pm 0.55$	$\pm 0.70 \times \pm 0.60$	$\pm 1.2 \times \pm 0.95$	$\pm 1.8 \times \pm 4.9$	$\pm 1.2 \times \pm 4.9$
Transmission to B' (no target at B)	3%	4%	11%	88%	59%
Transmission to B' (2" W target at B)	1%	1.5%	4%	29%	19%

TABLE III

Exclusive Settings for B5

Magnet	Polarity	Current (amp)	Shunt (mv)	Computer (counts)
Q1	B	2465	61.63	2465
Q2	B	2465	61.63	2465
Q3	B	2469	61.73	2469
Q4	A	1489	59.56	2382
Q5	A	1489	59.56	2382
D1	B	1070	26.75	1070
D2	B	1070	26.75	1070
D3			Off	
D4			Off	
Q6	AA	1488	49.60	1984
Q7	B	2002	66.73	2669
P1		As required		
D5	B	2750	68.75	2750

NOTE: If D1 is not ramped, reverse polarities of Qy and Q7.

XMAX	DX1	YMAX	DY1	P	DP	1 %
4.000	0.00100	4.000	0.00100	28.500	0.010	
0.036						XIV
0.072						XIV
0.108						X I+Y
0.144						X I-Y
0.180						X I-Y
0.216						X I-Y
0.252						X I-Y
0.303	01					X I-Y
0.356	02					X I-Y
0.418	03					X I-Y
0.474	04					X I-Y
0.521	05					X I-Y
0.558	05					X I-Y
0.617						X I-Y
0.677						X I-Y
0.706						X I-Y
0.736						X I-Y
0.765	D1					X I-Y
0.795	D1					X I-Y
0.824	D2					X I-Y
0.854	D2					X I-Y
0.883	D2					X I-Y
0.913						X I-Y
0.942						X I-Y
0.972	D3					X I-Y
1.001	D3					X I-Y
1.030						X I-Y
1.060	WALL					X I-Y
1.089	WALL					X I-Y
1.118	WALL					X I-Y
1.147	WALL					X I-Y
1.176	WALL					X I-Y
1.206	WALL					X I-Y
1.235	WALL					X I-Y
1.264	WALL					X I-Y
1.293	WALL					X I-Y
1.322	WALL					X I-Y
1.351	WALL					X I-Y
1.381	WALL					X I-Y
1.410	D4					X I-Y
1.439	D4					X I-Y
1.468						X I-Y
1.497						X I-Y
1.526						X I-Y
1.555						X I-Y
1.584						X I-Y
1.613						X I-Y
1.642						X I-Y
1.671						X I-Y
1.700						X I-Y
1.729						X I-Y
1.758						X I-Y
1.787						X I-Y
1.816						X I-Y
1.845						X I-Y
1.874						X I-Y
1.903						X I-Y
1.932						X I-Y
1.961						X I-Y
1.990						X I-Y
2.019						X I-Y
2.048						X I-Y
2.077						X I-Y
2.106						X I-Y
2.135						X I-Y
2.164						X I-Y
2.193						X I-Y
2.222						X I-Y
2.251						X I-Y
2.280						X I-Y
2.309						X I-Y
2.338						X I-Y
2.367						X I-Y
2.396						X I-Y
2.425						X I-Y
2.454						X I-Y
2.483						X I-Y
2.512						X I-Y
2.541						X I-Y
2.570						X I-Y
2.599						X I-Y
2.628						X I-Y
2.657						X I-Y
2.686						X I-Y
2.715						X I-Y
2.744						X I-Y
2.773						X I-Y
2.802						X I-Y
2.831						X I-Y
2.860						X I-Y
2.889						X I-Y
2.918						X I-Y
2.947						X I-Y
2.976						X I-Y
3.005						X I-Y
3.034						X I-Y
3.063						X I-Y
3.092						X I-Y
3.121						X I-Y
3.150						X I-Y
3.179						X I-Y
3.208						X I-Y
3.237						X I-Y
3.266						X I-Y
3.295						X I-Y
3.324						X I-Y
3.353						X I-Y
3.382						X I-Y
3.411						X I-Y
3.440						X I-Y
3.469						X I-Y
3.498						X I-Y
3.527						X I-Y
3.556						X I-Y
3.585						X I-Y
3.614						X I-Y
3.643						X I-Y
3.672						X I-Y
3.701						X I-Y
3.730						X I-Y
3.759						X I-Y
3.788						X I-Y
3.817						X I-Y
3.846						X I-Y
3.875						X I-Y
3.904						X I-Y
3.933						X I-Y
3.962						X I-Y
3.991						X I-Y
4.020						X I-Y
4.049						X I-Y
4.078						X I-Y
4.107						X I-Y
4.136						X I-Y
4.165						X I-Y
4.194						X I-Y
4.223						X I-Y
4.252						X I-Y
4.281						X I-Y
4.310						X I-Y
4.339						X I-Y
4.368						X I-Y
4.397						X I-Y
4.426						X I-Y
4.455						X I-Y
4.484						X I-Y
4.513						X I-Y
4.542						X I-Y
4.571						X I-Y
4.600						X I-Y
4.629						X I-Y
4.658						X I-Y
4.687						X I-Y
4.716						X I-Y
4.745						X I-Y
4.774						X I-Y
4.803						X I-Y
4.832						X I-Y
4.861						X I-Y
4.890						X I-Y
4.919						X I-Y
4.948						X I-Y
4.977						X I-Y
5.006						X I-Y
5.035						X I-Y
5.064						X I-Y
5.093						X I-Y
5.122						X I-Y
5.151						X I-Y
5.180						X I-Y
5.209						X I-Y
5.238						X I-Y
5.267						X I-Y
5.296						X I-Y
5.325						X I-Y
5.354						X I-Y
5.383						X I-Y
5.412						X I-Y
5.441						X I-Y
5.470						X I-Y
5.499						X I-Y
5.528						X I-Y
5.557						X I-Y
5.586						X I-Y
5.615						X I-Y
5.644						X I-Y
5.673						X I-Y
5.702						X I-Y
5.731						X I-Y
5.760						X I-Y
5.789						X I-Y
5.818						X I-Y
5.847						X I-Y
5.876						X I-Y
5.905						X I-Y
5.934						X I-Y
5.963						X I-Y
5.992						X I-Y
6.021						X I-Y
6.050						X I-Y
6.079						X I-Y
6.108						X I-Y
6.137						X I-Y
6.166						X I-Y
6.195						X I-Y
6.224						X I-Y
6.253						X I-Y
6.282						X I-Y
6.311						X I-Y
6.340						X I-Y
6.369						X I-Y
6.398						X I-Y
6.427						X I-Y
6.456						X I-Y
6.485						X I-Y
6.514						X I-Y
6.543						X I-Y
6.572						X I-Y
6.601						X I-Y
6.630						X I-Y
6.659						X I-Y
6.688						X I-Y
6.717						X I-Y
6.746						X I-Y
6.775						X I-Y
6.804						X I-Y
6.833						X I-Y
6.862						X I-Y
6.891						X I-Y
6.920						X I-Y
6.949						X I-Y
6.978						X I-Y
7.007						X I-Y
7.036						X I-Y
7.065						X I-Y
7.094						X I-Y
7.123						X I-Y
7.152						X I-Y
7.181						X I-Y
7.210						X I-Y
7.239						X I-Y
7.268						X I-Y
7.297						X I-Y
7.326						X I-Y
7.355						X I-Y
7.384						X I-Y
7.413						X I-Y
7.442						X I-Y
7.471						X I-Y
7.500						X I-Y
7.529						X I-Y
7.558						X I-Y
7.587						X I-Y
7.616						X I-Y
7.645						X I-Y
7.674						X I-Y
7.703						X I-Y
7.732						X I-Y
7.761						X I-Y
7.790						X I-Y
7.819						X I-Y
7.848						X I-Y
7.877						X I-Y
7.906						X I-Y
7.935						X I-Y
7.964						X I-Y
7.993						X I-Y
8.022						X I-Y
8.051						X I-Y
8.080						X I-Y
8.109						X I-Y
8.138						X I-Y
8.167						X I-Y
8.196						X I-Y
8.225						X I-Y
8.254						X I-Y
8.283						X I-Y
8.312						X I-Y
8.341						X I-Y
8.370						X I-Y
8.399						X I-Y
8.428						X I-Y
8.457						X I-Y
8.486						X I-Y
8.515						X I-Y
8.544						X I-Y
8.573						X I-Y
8.602						X I-Y
8.631					</	

YMAX	DX1	YMAX	DX1	P	DP	YMAX	DX1	YMAX	DX1
4.000	0.00100	4.000	0.00100	28.500	0.010	4.000	0.00100	4.000	0.00100
1 mr		1 mr		1 %		1 mr		1 mr	
0.036			XIY						
0.072			XIY						
0.108			XI-Y						
0.144			XI-Y						
0.180			XI-Y						
0.216			XI-Y						
0.245			XI-Y						
0.266			XI-Y						
0.277			XI-Y						
0.279			XI-Y						
0.286			XI-Y						
0.302			XI-Y						
0.326			XI-Y						
0.356			XI-Y						
0.387			XI-Y						
0.418			XI-Y						
0.448			XI-Y						
0.479			XI-Y						
0.509			XI-Y						
0.540			XI-Y						
0.571			XI-Y						
0.601			XI-Y						
0.632			XI-Y						
0.662			XI-Y						
0.693			XI-Y						
0.723			XI-Y						
0.754			XI-Y						
0.785			XI-Y						
0.815			XI-Y						
0.846			XI-Y						
0.876			XI-Y						
0.907			XI-Y						
0.938			XI-Y						
0.968			XI-Y						
0.999			XI-Y						
1.029			XI-Y						
1.060			XI-Y						
1.090			XI-Y						
1.121			XI-Y						
1.152			XI-Y						
1.182			XI-Y						
1.213			XI-Y						
1.243			XI-Y						
1.274			XI-Y						
1.304			XI-Y						
1.334			XI-Y						
1.364			XI-Y						
1.394			XI-Y						
1.424			XI-Y						
1.454			XI-Y						
1.484			XI-Y						
1.514			XI-Y						
1.544			XI-Y						
1.574			XI-Y						
1.604			XI-Y						
1.634			XI-Y						
1.664			XI-Y						
1.694			XI-Y						
1.724			XI-Y						
1.754			XI-Y						
1.784			XI-Y						
1.814			XI-Y						
1.844			XI-Y						
1.874			XI-Y						
1.904			XI-Y						
1.934			XI-Y						
1.964			XI-Y						
1.994			XI-Y						
2.024			XI-Y						
2.054			XI-Y						
2.084			XI-Y						
2.114			XI-Y						
2.144			XI-Y						
2.174			XI-Y						
2.204			XI-Y						
2.234			XI-Y						
2.264			XI-Y						
2.294			XI-Y						
2.324			XI-Y						
2.354			XI-Y						
2.384			XI-Y						
2.414			XI-Y						
2.444			XI-Y						
2.474			XI-Y						
2.504			XI-Y						
2.534			XI-Y						
2.564			XI-Y						
2.594			XI-Y						
2.624			XI-Y						
2.654			XI-Y						
2.684			XI-Y						
2.714			XI-Y						
2.744			XI-Y						
2.774			XI-Y						
2.804			XI-Y						
2.834			XI-Y						
2.864			XI-Y						
2.894			XI-Y						
2.924			XI-Y						
2.954			XI-Y						
2.984			XI-Y						
3.014			XI-Y						
3.044			XI-Y						
3.074			XI-Y						
3.104			XI-Y						
3.134			XI-Y						
3.164			XI-Y						
3.194			XI-Y						
3.224			XI-Y						
3.254			XI-Y						
3.284			XI-Y						
3.314			XI-Y						
3.344			XI-Y						
3.374			XI-Y						
3.404			XI-Y						
3.434			XI-Y						
3.464			XI-Y						
3.494			XI-Y						
3.524			XI-Y						
3.554			XI-Y						
3.584			XI-Y						
3.614			XI-Y						
3.644			XI-Y						
3.674			XI-Y						
3.704			XI-Y						
3.734			XI-Y						
3.764			XI-Y						
3.794			XI-Y						
3.824			XI-Y						
3.854			XI-Y						
3.884			XI-Y						
3.914			XI-Y						
3.944			XI-Y						
3.974			XI-Y						
4.004			XI-Y						

Figure 2. B5 with B1 at 12GeV/c

B5BEAM 08/27/74

XMAX	DX1	YMAX	DY1	P	DP	I %
4.000	0.00100	4.000	0.00100	28.500	0.010	
0.036						XIY
0.072						XIY
0.108						XI-Y
0.144						XI-Y
0.180						XI-Y
0.216	Q1					XI-Y
0.240						XI-Y
0.252	Q2					XI-Y
0.248	Q3					XI-Y
0.230	Q4					XI-Y
0.219	Q5					XI-Y
0.218						XI-Y
0.228	Q5					XI-Y
0.246						XI-Y
0.263						XI-Y
0.281						XI-Y
0.299						XI-Y
0.316						XI-Y
0.334						XI-Y
0.351						XI-Y
0.369	D1					XI-Y
0.386	D2					XI-Y
0.404	D2					XI-Y
0.422						XI-Y
0.439						XI-Y
0.457						XI-Y
0.474	D3					XI-Y
0.492	D3					XI-Y
0.509						XI-Y
0.527	WALL					XI-Y
0.545	WALL					XI-Y
0.562	WALL					XI-Y
0.580	WALL					XI-Y
0.597	WALL					XI-Y
0.615	WALL					XI-Y
0.632	WALL					XI-Y
0.650	WALL					XI-Y
0.668	WALL					XI-Y
0.685	WALL					XI-Y
0.703	WALL					XI-Y
0.720	WALL					XI-Y
0.738	D4					XI-Y
0.755						XI-Y
0.773	Q6					XI-Y
0.791						XI-Y
1.177	Q7					XI-Y
1.100						XI-Y
0.942						XI-Y
0.785						XI-Y
0.628						XI-Y
0.471						XI-Y
0.314						XI-Y
0.157						XI-Y
-0.000						XIY

B5BEAM 08/27/74

Figure 3. B5 with B1 at 20GeV/c

- 0.036
- 0.072
- 0.108
- 0.144
- 0.180
- 0.216
- 0.263
- 0.326
- 0.407
- 0.512
- 0.600
- 0.660
- 0.686
- 0.691
- 0.695
- 0.699
- 0.703
- 0.708
- 0.712
- 0.716
- 0.720
- 0.724
- 0.728
- 0.732
- 0.735
- 0.739
- 0.743
- 0.746
- 0.750
- 0.753
- 0.757
- 0.760
- 0.764
- 0.767
- 0.771
- 0.774
- 0.778
- 0.781
- 0.784
- 0.788
- 0.791
- 0.795
- 0.798
- 0.781
- 0.620
- 0.440
- 0.362
- 0.310
- 0.258
- 0.207
- 0.155
- 0.103
- 0.052
- 0.000

Figure 4. Ray trace from B target to upstream flag



