BROOKHAVEN NATIONAL LABORATORY
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EP&S DIVISION TECHNICAL NOTE

No. 72

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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		as required		
12	D5	B	2750	68.75	2750
	D3	B	836	20.90	836
	D4	A	91	11.40	455
	Q6	B	1663	55.43	2217
	Q7	A	2273	75.77	3031
8	P1		as required		
	D5	B	2750	68.75	2750
	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		as required		
	D5	B	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 (mr H x mr 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	
	1 m		1 m			
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
0.288						X I-Y
0.324						X I-Y
0.360						X I-Y
0.396						X I-Y
0.432						X I-Y
0.468						X I-Y
0.504						X I-Y
0.540						X I-Y
0.576						X I-Y
0.612						X I-Y
0.648						X I-Y
0.684						X I-Y
0.720						X I-Y
0.756						X I-Y
0.792						X I-Y
0.828						X I-Y
0.864						X I-Y
0.900						X I-Y
0.936						X I-Y
0.972						X I-Y
1.008						X I-Y
1.044						X I-Y
1.080						X I-Y
1.116						X I-Y
1.152						X I-Y
1.188						X I-Y
1.224						X I-Y
1.260						X I-Y
1.296						X I-Y
1.332						X I-Y
1.368						X I-Y
1.404						X I-Y
1.440						X I-Y
1.476						X I-Y
1.512						X I-Y
1.548						X I-Y
1.584						X I-Y
1.620						X I-Y
1.656						X I-Y
1.692						X I-Y
1.728						X I-Y
1.764						X I-Y
1.800						X I-Y
1.836						X I-Y
1.872						X I-Y
1.908						X I-Y
1.944						X I-Y
1.980						X I-Y
2.016						X I-Y
2.052						X I-Y
2.088						X I-Y
2.124						X I-Y
2.160						X I-Y
2.196						X I-Y
2.232						X I-Y
2.268						X I-Y
2.304						X I-Y
2.340						X I-Y
2.376						X I-Y
2.412						X I-Y
2.448						X I-Y
2.484						X I-Y
2.520						X I-Y
2.556						X I-Y
2.592						X I-Y
2.628						X I-Y
2.664						X I-Y
2.700						X I-Y
2.736						X I-Y
2.772						X I-Y
2.808						X I-Y
2.844						X I-Y
2.880						X I-Y
2.916						X I-Y
2.952						X I-Y
2.988						X I-Y
3.024						X I-Y
3.060						X I-Y
3.096						X I-Y
3.132						X I-Y
3.168						X I-Y
3.204						X I-Y
3.240						X I-Y
3.276						X I-Y
3.312						X I-Y
3.348						X I-Y
3.384						X I-Y
3.420						X I-Y
3.456						X I-Y
3.492						X I-Y
3.528						X I-Y
3.564						X I-Y
3.600						X I-Y
3.636						X I-Y
3.672						X I-Y
3.708						X I-Y
3.744						X I-Y
3.780						X I-Y
3.816						X I-Y
3.852						X I-Y
3.888						X I-Y
3.924						X I-Y
3.960						X I-Y
3.996						X I-Y
4.032						X I-Y
4.068						X I-Y
4.104						X I-Y
4.140						X I-Y
4.176						X I-Y
4.212						X I-Y
4.248						X I-Y
4.284						X I-Y
4.320						X I-Y
4.356						X I-Y
4.392						X I-Y
4.428						X I-Y
4.464						X I-Y
4.500						X I-Y
4.536						X I-Y
4.572						X I-Y
4.608						X I-Y
4.644						X I-Y
4.680						X I-Y
4.716						X I-Y
4.752						X I-Y
4.788						X I-Y
4.824						X I-Y
4.860						X I-Y
4.896						X I-Y
4.932						X I-Y
4.968						X I-Y
5.004						X I-Y
5.040						X I-Y
5.076						X I-Y
5.112						X I-Y
5.148						X I-Y
5.184						X I-Y
5.220						X I-Y
5.256						X I-Y
5.292						X I-Y
5.328						X I-Y
5.364						X I-Y
5.400						X I-Y
5.436						X I-Y
5.472						X I-Y
5.508						X I-Y
5.544						X I-Y
5.580						X I-Y
5.616						X I-Y
5.652						X I-Y
5.688						X I-Y
5.724						X I-Y
5.760						X I-Y
5.796						X I-Y
5.832						X I-Y
5.868						X I-Y
5.904						X I-Y
5.940						X I-Y
5.976						X I-Y
6.012						X I-Y
6.048						X I-Y
6.084						X I-Y
6.120						X I-Y
6.156						X I-Y
6.192						X I-Y
6.228						X I-Y
6.264						X I-Y
6.300						X I-Y
6.336						X I-Y
6.372						X I-Y
6.408						X I-Y
6.444						X I-Y
6.480						X I-Y
6.516						X I-Y
6.552						X I-Y
6.588						X I-Y
6.624						X I-Y
6.660						X I-Y
6.696						X I-Y
6.732						X I-Y
6.768						X I-Y
6.804						X I-Y
6.840						X I-Y
6.876						X I-Y
6.912						X I-Y
6.948						X I-Y
6.984						X I-Y
7.020						X I-Y
7.056						X I-Y
7.092						X I-Y
7.128						X I-Y
7.164						X I-Y
7.200						X I-Y
7.236						X I-Y
7.272						X I-Y
7.308						X I-Y
7.344						X I-Y
7.380						X I-Y
7.416						X I-Y
7.452						X I-Y
7.488						X I-Y
7.524						X I-Y
7.560						X I-Y
7.596						X I-Y
7.632						X I-Y
7.668						X I-Y
7.704						X I-Y
7.740						X I-Y
7.776						X I-Y
7.812						X I-Y
7.848						X I-Y
7.884						X I-Y
7.920						X I-Y
7.956						X I-Y
7.992						X I-Y
8.028						X I-Y
8.064						X I-Y
8.100						X I-Y
8.136						X I-Y
8.172						X I-Y
8.208						X I-Y
8.244						X I-Y
8.280						X I-Y
8.316						X I-Y
8.352						X I-Y
8.388						X I-Y
8.424						X I-Y
8.460						X I-Y
8.496						X I-Y
8.532						X I-Y
8.568						X I-Y
8.604						X I-Y
8.640						X I-Y
8.676						X I-Y
8.712						X I-Y
8.748						X I-Y
8.784						X I-Y
8.820						X I-Y
8.856						X I-Y
8.892						X I-Y
8.928						X I-Y
8.964						X I-Y
9.000						X I-Y
9.036						X I-Y
9.072						X I-Y
9.108						X I-Y
9.144						X I-Y
9.180						X I-Y
9.216						X I-Y
9.252						X I-Y
9.288						X I-Y
9.324						X I-Y
9.360						X I-Y
9.396						X I-Y
9.432						X I-Y
9.468						X I-Y
9.504						X I-Y
9.540						X I-Y
9.576						X I-Y
9.612						X I-Y
9.648						X I-Y
9.684						X I-Y
9.720						X I-Y
9.756						X I-Y
9.792						X I-Y
9.828						X I-Y
9.864						X I-Y
9.900						X I-Y
9.936						X I-Y
9.972						X I-Y
10.008						X I-Y
10.044						X I-Y
10.080						X I-Y
10.116						X I-Y
10.152						X I-Y
10.188						X I-Y
10.224						

[illegible]

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XMAX	DX1	YMAX	DY1	P	DP	1 %	1 mr
4.000	0.00100	4.000	0.00100	28.500	0.010		
0.036						XIY	0.036
0.072						XIY	0.072
0.108						X I-Y	0.108
0.144						X I-Y	0.144
0.180						X I-Y	0.180
0.216						X I-Y	0.216
0.240						X I-Y	0.240
0.252						X I-Y	0.252
0.248						X I-Y	0.248
0.230						X I-Y	0.230
0.219						X I-Y	0.219
0.218						X I-Y	0.218
0.228						X I-Y	0.228
0.246						X I-Y	0.246
0.263						X I-Y	0.263
0.281						X I-Y	0.281
0.299						X I-Y	0.299
0.316						X I-Y	0.316
0.334						X I-Y	0.334
0.351						X I-Y	0.351
0.369						X I-Y	0.369
0.386						X I-Y	0.386
0.404						X I-Y	0.404
0.422						X I-Y	0.422
0.439						X I-Y	0.439
0.457						X I-Y	0.457
0.474						X I-Y	0.474
0.492						X I-Y	0.492
0.509						X I-Y	0.509
0.527						X I-Y	0.527
0.545						X I-Y	0.545
0.562						X I-Y	0.562
0.580						X I-Y	0.580
0.597						X I-Y	0.597
0.615						X I-Y	0.615
0.632						X I-Y	0.632
0.650						X I-Y	0.650
0.668						X I-Y	0.668
0.685						X I-Y	0.685
0.703						X I-Y	0.703
0.720						X I-Y	0.720
0.738						X I-Y	0.738
0.755						X I-Y	0.755
0.773						X I-Y	0.773
0.791						X I-Y	0.791
0.809						X I-Y	0.809
0.827						X I-Y	0.827
0.845						X I-Y	0.845
0.863						X I-Y	0.863
0.881						X I-Y	0.881
0.899						X I-Y	0.899
0.917						X I-Y	0.917
0.935						X I-Y	0.935
0.953						X I-Y	0.953
0.971						X I-Y	0.971
0.989						X I-Y	0.989
1.007						X I-Y	1.007
1.025						X I-Y	1.025
1.043						X I-Y	1.043
1.061						X I-Y	1.061
1.079						X I-Y	1.079
1.097						X I-Y	1.097
1.115						X I-Y	1.115
1.133						X I-Y	1.133
1.151						X I-Y	1.151
1.169						X I-Y	1.169
1.187						X I-Y	1.187
1.205						X I-Y	1.205
1.223						X I-Y	1.223
1.241						X I-Y	1.241
1.259						X I-Y	1.259
1.277						X I-Y	1.277
1.295						X I-Y	1.295
1.313						X I-Y	1.313
1.							

Figure 4. Ray trace from B target to upstream flag

XMAX	DX1	YMAX	OY1	P	DP	
4.000	0.00200	4.000	0.00500	28.500	0.010	1 %
	2 m		5 m			
0.072						XI - Y
0.144						XI -
0.216						XI -
0.288						XI -
0.360						XI -
0.432						XI -
0.504						XI -
0.576						XI -
0.648						XI -
0.720						XI -
0.792						XI -
0.864						XI -
0.936						XI -
1.008						XI -
1.080						XI -
1.152						XI -
1.224						XI -
1.296						XI -
1.368						XI -
1.440						XI -
1.512						XI -
1.584						XI -
1.656						XI -
1.728						XI -
1.800						XI -
1.872						XI -
1.944						XI -
2.016						XI -
2.088						XI -
2.160						XI -
2.232						XI -
2.304						XI -
2.376						XI -
2.448						XI -
2.520						XI -
2.592						XI -
2.664						XI -
2.736						XI -
2.808						XI -
2.880						XI -
2.952						XI -
3.024						XI -
3.096						XI -
3.168						XI -
3.240						XI -
3.312						XI -
3.384						XI -
3.456						XI -
3.528						XI -
3.600						XI -
3.672						XI -
3.744						XI -
3.816						XI -
3.888						XI -
3.960						XI -
4.032						XI -
4.104						XI -
4.176						XI -
4.248						XI -
4.320						XI -
4.392						XI -
4.464						XI -
4.536						XI -
4.608						XI -
4.680						XI -
4.752						XI -
4.824						XI -
4.896						XI -
4.968						XI -
5.040						XI -
5.112						XI -
5.184						XI -
5.256						XI -
5.328						XI -
5.400						XI -
5.472						XI -
5.544						XI -
5.616						XI -
5.688						XI -
5.760						XI -
5.832						XI -
5.904						XI -
5.976						XI -
6.048						XI -
6.120						XI -
6.192						XI -
6.264						XI -
6.336						XI -
6.408						XI -
6.480						XI -
6.552						XI -
6.624						XI -
6.696						XI -
6.768						XI -
6.840						XI -
6.912						XI -
6.984						XI -
7.056						XI -
7.128						XI -
7.200						XI -
7.272						XI -
7.344						XI -
7.416						XI -
7.488						XI -
7.560						XI -
7.632						XI -
7.704						XI -
7.776						XI -
7.848						XI -
7.920						XI -
7.992						XI -
8.064						XI -
8.136						XI -
8.208						XI -
8.280						XI -
8.352						XI -
8.424						XI -
8.496						XI -
8.568						XI -
8.640						XI -
8.712						XI -
8.784						XI -
8.856						XI -
8.928						XI -
9.000						XI -
9.072						XI -
9.144						XI -
9.216						XI -
9.288						XI -
9.360						XI -
9.432						XI -
9.504						XI -
9.576						XI -
9.648						XI -
9.720						XI -
9.792						XI -
9.864						XI -
9.936						XI -
10.008						XI -
10.080						XI -
10.152						XI -
10.224						XI -
10.296						XI -
10.368						XI -
10.440						XI -
10.512						XI -
10.584						XI -
10.656						XI -
10.728						XI -
10.800						XI -
10.872						XI -
10.944						XI -
11.016						XI -
11.088						XI -
11.160						XI -
11.232						XI -
11.304						XI -
11.376						XI -
11.448						XI -
11.520						XI -
11.592						XI -
11.664						XI -
11.736						XI -
11.808						XI -
11.880						XI -
11.952						XI -
12.024						XI -
12.096						XI -
12.168						XI -
12.240						XI -
12.312						XI -
12.384						XI -
12.456						XI -
12.528						XI -
12.600						XI -
12.672						XI -
12.744						XI -
12.816						XI -
12.888						XI -
12.960						XI -
13.032						XI -
13.104						XI -
13.176						XI -
13.248						XI -
13.320						XI -
13.392						XI -
13.464						XI -
13.536						XI -
13.608						XI -
13.680						XI -
13.752						XI -
13.824						XI -
13.896						XI -
13.968						XI -
14.040						XI -
14.112						XI -
14.184						XI -
14.256						XI -
14.328						XI -
14.400						XI -
14.472						XI -
14.544						XI -
14.616						XI -
14.688						XI -
14.760						XI -
14.832						XI -
14.904						XI -
14.976						XI -
15.048						XI -
15.120						XI -
15.192						XI -
15.264						XI -
15.336						XI -
15.408						XI -
15.480						XI -
15.552						XI -
15.624						XI -
15.696						XI -
15.768						XI -
15.840						XI -
15.912						XI -
15.984						XI -
16.056						XI -
16.128						XI -
16.200						XI -
16.272						XI -
16.344						XI -
16.416						XI -
16.488						XI -
16.560						XI -
16.632						XI -
16.704						XI -
16.776						XI -
16.848						XI -
16.920						XI -
16.992						XI -
17.064						XI -
17.136						XI -
17.208						XI -
17.280						XI -
17.352						XI -
17.424						XI -
17.496						XI -
17.568						XI -
17.640						XI -
17.712						XI -
17.784						XI -
17.856						XI -
17.928						XI -
18.000						XI -
18.072						XI -
18.144						XI -
18.216						XI -
18.288						XI -
18.360						XI -
18.432						XI -
18.504						XI -
18.576						XI -
18.648						XI -
18.720						XI -
18.792						XI -
18.864						XI -
18.936						XI -
19.008						XI -
19.080						XI -
19.152						XI -
19.224						XI -
19.296						XI -
19.368						XI -
19.440						XI -
19.512						XI -
19.584						XI -
19.656						XI -
19.728						XI -
19.800						XI -
19.872						XI -
19.944						XI -
20.016						XI -
20.088						XI -
20.160						XI -
20						