

Optics of Beam #B5

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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

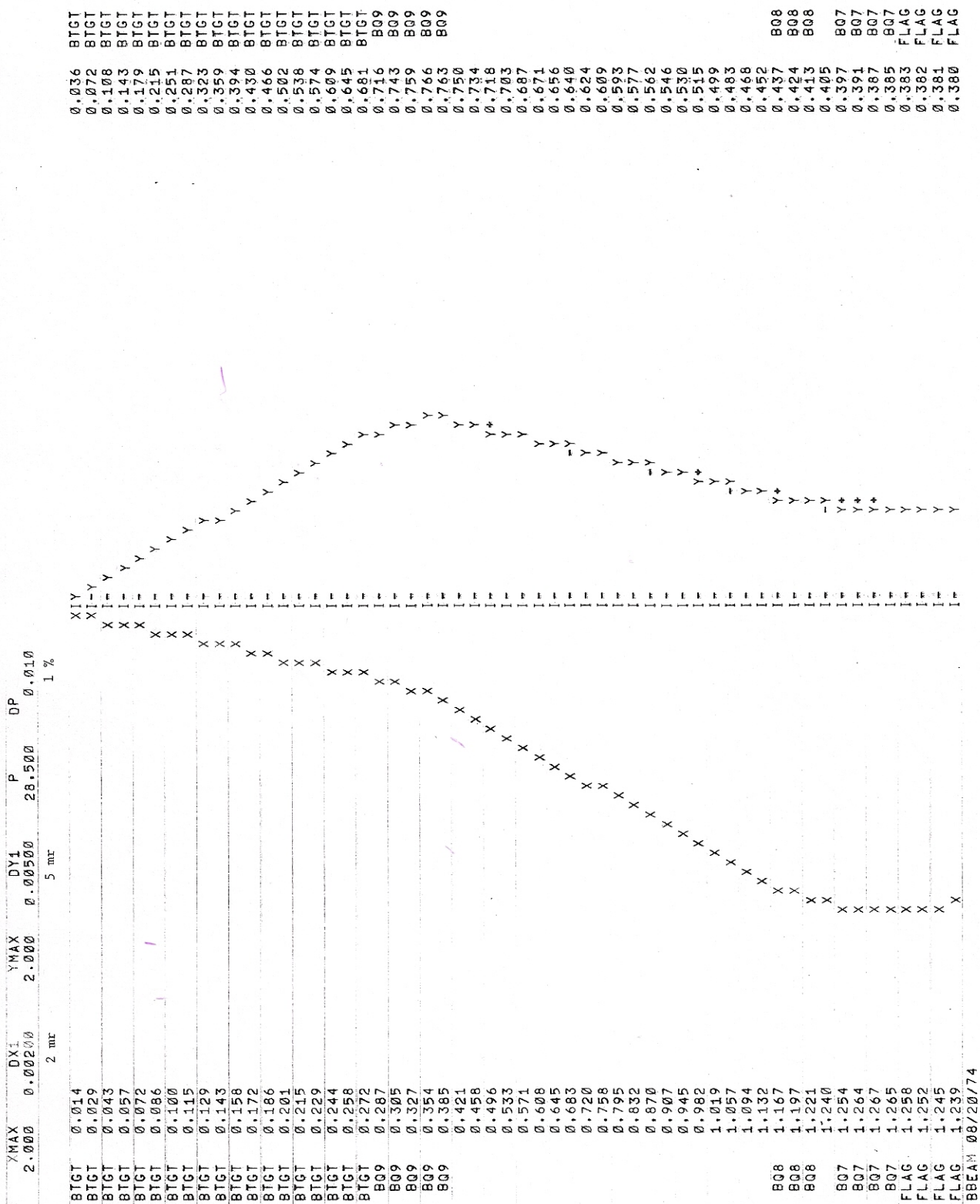
NOTE: If D1 is not ramped, reverse polarities of Qy and Q7.

XMAX	DX1	YMAX	DY1	P	DP	1 %
4.000	0.00100	4.000	0.00100	28.500	0.010	1 %
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
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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						X I-Y
10.26						

XMAX	DX1	YMAX	DY1	P	DP	
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0.180			X I-Y			0.180
0.216			X I-Y			0.216
0.252			X I-Y			0.252
0.288			X I-Y			0.288
0.324			X I-Y			0.324
0.360			X I-Y			0.360
0.396			X I-Y			0.396
0.432			X I-Y			0.432
0.468			X I-Y			0.468
0.504			X I-Y			0.504
0.540			X I-Y			0.540
0.576			X I-Y			0.576
0.612			X I-Y			0.612
0.648			X I-Y			0.648
0.684			X I-Y			0.684
0.720			X I-Y			0.720
0.756			X I-Y			0.756
0.792			X I-Y			0.792
0.828			X I-Y			0.828
0.864			X I-Y			0.864
0.900			X I-Y			0.900
0.936			X I-Y			0.936
0.972			X I-Y			0.972
1.008			X I-Y			1.008
1.044			X I-Y			1.044
1.080			X I-Y			1.080
1.116			X I-Y			1.116
1.152			X I-Y			1.152
1.188			X I-Y			1.188
1.224			X I-Y			1.224
1.260			X I-Y			1.260
1.296			X I-Y			1.296
1.332			X I-Y			1.332
1.368			X I-Y			1.368
1.404			X I-Y			1.404
1.440			X I-Y			1.440
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1.512			X I-Y			1.512
1.548			X I-Y			1.548
1.584			X I-Y			1.584
1.620			X I-Y			1.620
1.656			X I-Y			1.656
1.692			X I-Y			1.692
1.728			X I-Y			1.728
1.764			X I-Y			1.764
1.800			X I-Y			1.800
1.836			X I-Y			1.836
1.872			X I-Y			1.872
1.908			X I-Y			1.908
1.944			X I-Y			1.944
1.980			X I-Y			1.980
2.016			X I-Y			2.016
2.052			X I-Y			2.052
2.088			X I-Y			2.088
2.124			X I-Y			2.124
2.160			X I-Y			2.160
2.196			X I-Y			2.196
2.232			X I-Y			2.232
2.268			X I-Y			2.268
2.304			X I-Y			2.304
2.340			X I-Y			2.340
2.376			X I-Y			2.376
2.412			X I-Y			2.412
2.448			X I-Y			2.448
2.484			X I-Y			2.484
2.520			X I-Y			2.520
2.556			X I-Y			2.556
2.592			X I-Y			2.592
2.628			X I-Y			2.628
2.664			X I-Y			2.664
2.700			X I-Y			2.700
2.736			X I-Y			2.736
2.772			X I-Y			2.772
2.808			X I-Y			2.808
2.844			X I-Y			2.844
2.880			X I-Y			2.880
2.916			X I-Y			2.916
2.952			X I-Y			2.952
2.988			X I-Y			2.988
3.024			X I-Y			3.024
3.060			X I-Y			3.060
3.096			X I-Y			3.096
3.132			X I-Y			3.132
3.168			X I-Y			3.168
3.204			X I-Y			3.204
3.240			X I-Y			3.240
3.276			X I-Y			3.276
3.312			X I-Y			3.312
3.348			X I-Y			3.348
3.384			X I-Y			3.384
3.420			X I-Y			3.420
3.456			X I-Y			3.456
3.492			X I-Y			3.492
3.528			X I-Y			3.528
3.564			X I-Y			3.564
3.600			X I-Y			3.600
3.636			X I-Y			3.636
3.672			X I-Y			3.672
3.708			X I-Y			3.708
3.744			X I-Y			3.744
3.780			X I-Y			3.780
3.816			X I-Y			3.816
3.852			X I-Y			3.852
3.888			X I-Y			3.888
3.924			X I-Y			3.924
3.960			X I-Y			3.960
3.996			X I-Y			3.996
4.032			X I-Y			4.032
4.068			X I-Y			4.068
4.104			X I-Y			4.104
4.140			X I-Y			4.140
4.176			X I-Y			4.176
4.212			X I-Y			4.212
4.248			X I-Y			4.248
4.284			X I-Y			4.284
4.320			X I-Y			4.320
4.356			X I-Y			4.356
4.392			X I-Y			4.392
4.428			X I-Y			4.428
4.464			X I-Y			4.464
4.500			X I-Y			4.500
4.536			X I-Y			4.536
4.572			X I-Y			4.572
4.608			X I-Y			4.608
4.644			X I-Y			4.644
4.680			X I-Y			4.680
4.716			X I-Y			4.716
4.752			X I-Y			4.752
4.788			X I-Y			4.788
4.824			X I-Y			4.824
4.860			X I-Y			4.860
4.896			X I-Y			4.896
4.932			X I-Y			4.932
4.968			X I-Y			4.968
5.004			X I-Y			5.004
5.040			X I-Y			5.040
5.076			X I-Y			5.076
5.112			X I-Y			5.112
5.148			X I-Y			5.148
5.184			X I-Y			5.184
5.220			X I-Y			5.220
5.256			X I-Y			5.256
5.292			X I-Y			5.292
5.328			X I-Y			5.328
5.364			X I-Y			5.364
5.400			X I-Y			5.400
5.436			X I-Y			5.436
5.472			X I-Y			5.472
5.508			X I-Y			5.508
5.544			X I-Y			5.544
5.580			X I-Y			5.580
5.616			X I-Y			5.616
5.652			X I-Y			5.652
5.688			X I-Y			5.688
5.724			X I-Y			5.724
5.760			X I-Y			5.760
5.796			X I-Y			5.796
5.832			X I-Y			5.832
5.868			X I-Y			5.868
5.904			X I-Y			5.904
5.940			X I-Y			5.940
5.976			X I-Y			5.976
6.012			X I-Y			6.012
6.048			X I-Y			6.048
6.084			X I-Y			6.084
6.120			X I-Y			6.120
6.156			X I-Y			6.156
6.192			X I-Y			6.192
6.228			X I-Y			6.228
6.264			X I-Y			6.264
6.300			X I-Y			6.300
6.336			X I-Y			6.336
6.372			X I-Y			6.372
6.408			X I-Y			6.408
6.444			X I-Y			6.444
6.480			X I-Y			6.480
6.516			X I-Y			6.516
6.552			X I-Y			6.552
6.588			X I-Y			6.588
6.624			X I-Y			6.624
6.660			X I-Y			6.660
6.696			X I-Y			6.696
6.732			X I-Y			6.732
6.768			X I-Y			6.768
6.804			X I-Y			6.804
6.840			X I-Y			6.840
6.876			X I-Y			6.876
6.912			X I-Y			6.912
6.948			X I-Y			6.948
6.984			X I-Y			6.984
7.020			X I-Y			7.020
7.056			X I-Y			7.056
7.092			X I-Y			7.092
7.128			X I-Y			7.128
7.164			X I-Y			7.164
7.200			X I-Y			7.200
7.236			X I-Y			7.236
7.272			X I-Y			7.272
7.308			X I-Y			7.308
7.344			X I-Y			7.344
7.380			X I-Y			7.380
7.416			X I-Y			7.416
7.452			X I-Y			7.452
7.488			X I-Y			7.488
7.524			X I-Y			7.524
7.560			X I-Y			7.560
7.596			X I-Y			7.596
7.632			X I-Y			7.632
7.668			X I-Y			7.668
7.704			X I-Y			7.704
7.740			X I-Y			7.740
7.776			X I-Y			7.776
7.812			X I-Y			7.812
7.848			X I-Y			7.848
7.884			X I-Y			7.884
7.920			X I-Y			7.920
7.956			X I-Y			7.956
7.992			X I-Y			7.992
8.028			X I-Y			8.028
8.064			X I-Y			8.064
8.100			X I-Y			8.100
8.136			X I-Y			8.136
8.172			X I-Y			8.172
8.208			X I-Y			8.208
8.244			X I-Y			8.244
8.280			X I-Y			8.280
8.316			X I-Y			8.316
8.352			X I-Y			8.352
8.388			X I-Y			8.388
8.424			X I-Y			8.424
8.460			X I-Y			8.460
8.496			X I-Y			8.496
8.532			X I-Y			8.532
8.568			X I-Y			8.568
8.604			X I-Y			8.604
8.640			X I-Y			8.640
8.676			X I-Y			8.676
8.712			X I-Y			8.712
8.748			X I-Y			8.748
8.784			X I-Y			8.784
8.820			X I-Y			8.820
8.856			X I-Y			8.856
8.892			X I-Y			8.892
8.928			X I-Y			8.928
8.964			X I-Y			8.964
9.000			X I-Y			

XMAX	DX1	YMAX	DP	P	DY1	1 %
4.000	0.00100	4.000	0.00100	28.500	0.00100	1 %
0.036	0.072	0.108	0.144	0.180	0.216	0.240
0.252	0.288	0.324	0.360	0.396	0.432	0.468
0.504	0.540	0.576	0.612	0.648	0.684	0.720
0.720	0.756	0.792	0.828	0.864	0.900	0.936
0.936	0.972	1.008	1.044	1.080	1.116	1.152
1.152	1.188	1.224	1.260	1.296	1.332	1.368
1.368	1.404	1.440	1.476	1.512	1.548	1.584
1.584	1.620	1.656	1.692	1.728	1.764	1.800
1.800	1.836	1.872	1.908	1.944	1.980	2.016
2.016	2.052	2.088	2.124	2.160	2.196	2.232
2.232	2.268	2.304	2.340	2.376	2.412	2.448
2.448	2.484	2.520	2.556	2.592	2.628	2.664
2.664	2.700	2.736	2.772	2.808	2.844	2.880
2.880	2.916	2.952	2.988	3.024	3.060	3.096
3.096	3.132	3.168	3.204	3.240	3.276	3.312
3.312	3.348	3.384	3.420	3.456	3.492	3.528
3.528	3.564	3.600	3.636	3.672	3.708	3.744
3.744	3.780	3.816	3.852	3.888	3.924	3.960
3.960	4.000	4.040	4.080	4.120	4.160	4.200
4.200	4.240	4.280	4.320	4.360	4.400	4.440
4.440	4.480	4.520	4.560	4.600	4.640	4.680
4.680	4.720	4.760	4.800	4.840	4.880	4.920
4.920	4.960	5.000	5.040	5.080	5.120	5.160
5.160	5.200	5.240	5.280	5.320	5.360	5.400
5.400	5.440	5.480	5.520	5.560	5.600	5.640
5.640	5.680	5.720	5.760	5.800	5.840	5.880
5.880	5.920	5.960	6.000	6.040	6.080	6.120
6.120	6.160	6.200	6.240	6.280	6.320	6.360
6.360	6.400	6.440	6.480	6.520	6.560	6.600
6.600	6.640	6.680	6.720	6.760	6.800	6.840
6.840	6.880	6.920	6.960	7.000	7.040	7.080
7.080	7.120	7.160	7.200	7.240	7.280	7.320
7.320	7.360	7.400	7.440	7.480	7.520	7.560
7.560	7.600	7.640	7.680	7.720	7.760	7.800
7.800	7.840	7.880	7.920	7.960	8.000	8.040
8.040	8.080	8.120	8.160	8.200	8.240	8.280
8.280	8.320	8.360	8.400	8.440	8.480	8.520
8.520	8.560	8.600	8.640	8.680	8.720	8.760
8.760	8.800	8.840	8.880	8.920	8.960	9.000
9.000	9.040	9.080	9.120	9.160	9.200	9.240
9.240	9.280	9.320	9.360	9.400	9.440	9.480
9.480	9.520	9.560	9.600	9.640	9.680	9.720
9.720	9.760	9.800	9.840	9.880	9.920	9.960
9.960	10.000	10.040	10.080	10.120	10.160	10.200
10.200	10.240	10.280	10.320	10.360	10.400	10.440
10.440	10.480	10.520	10.560	10.600	10.640	10.680
10.680	10.720	10.760	10.800	10.840	10.880	10.920
10.920	10.960	11.000	11.040	11.080	11.120	11.160
11.160	11.200	11.240	11.280	11.320	11.360	11.400
11.400	11.440	11.480	11.520	11.560	11.600	11.640
11.640	11.680	11.720	11.760	11.800	11.840	11.880
11.880	11.920	11.960	12.000	12.040	12.080	12.120
12.120	12.160	12.200	12.240	12.280	12.320	12.360
12.360	12.400	12.440	12.480	12.520	12.560	12.600
12.600	12.640	12.680	12.720	12.760	12.800	12.840
12.840	12.880	12.920	12.960	13.000	13.040	13.080
13.080	13.120	13.160	13.200	13.240	13.280	13.320
13.320	13.360	13.400	13.440	13.480	13.520	13.560
13.560	13.600	13.640	13.680	13.720	13.760	13.800
13.800	13.840	13.880	13.920	13.960	14.000	14.040
14.040	14.080	14.120	14.160	14.200	14.240	14.280
14.280	14.320	14.360	14.400	14.440	14.480	14.520
14.520	14.560	14.600	14.640	14.680	14.720	14.760
14.760	14.800	14.840	14.880	14.920	14.960	15.000
15.000	15.040	15.080	15.120	15.160	15.200	15.240
15.240	15.280	15.320	15.360	15.400	15.440	15.480
15.480	15.520	15.560	15.600	15.640	15.680	15.720
15.720	15.760	15.800	15.840	15.880	15.920	15.960
15.960	16.000	16.040	16.080	16.120	16.160	16.200
16.200	16.240	16.280	16.320	16.360	16.400	16.440
16.440	16.480	16.520	16.560	16.600	16.640	16.680
16.680	16.720	16.760	16.800	16.840	16.880	16.920
16.920	16.960	17.000	17.040	17.080	17.120	17.160
17.160	17.200	17.240	17.280	17.320	17.360	17.400
17.400	17.440	17.480	17.520	17.560	17.600	17.640
17.640	17.680	17.720	17.760	17.800	17.840	17.880
17.880	17.920	17.960	18.000	18.040	18.080	18.120
18.120	18.160	18.200	18.240	18.280	18.320	18.360
18.360	18.400	18.440	18.480	18.520	18.560	18.600
18.600	18.640	18.680	18.720	18.760	18.800	18.840
18.840	18.880	18.920	18.960	19.000	19.040	19.080
19.080	19.120	19.160	19.200	19.240	19.280	19.320
19.320	19.360	19.400	19.440	19.480	19.520	19.560
19.560	19.600	19.640	19.680	19.720	19.760	19.800
19.800	19.840	19.880	19.920	19.960	20.000	20.040
20.040	20.080	20.120	20.160	20.200	20.240	20.280
20.280	20.320	20.360	20.400	20.440	20.480	20.520
20.520	20.560	20.600	20.640	20.680	20.720	20.760
20.760	20.800	20.840	20.880	20.920	20.960	21.000
21.000	21.040	21.080	21.120	21.160	21.200	21.240
21.240	21.280	21.320	21.360	21.400	21.440	21.480
21.480	21.520	21.560	21.600	21.640	21.680	21.720
21.720	21.760	21.800	21.840	21.880	21.920	21.960
21.960	22.000	22.040	22.080	22.120	22.160	22.200
22.200	22.240	22.280	22.320	22.360	22.400	22.440
22.440	22.480	22.520	22.560	22.600	22.640	22.680
22.680	22.720	22.760	22.800	22.840	22.880	22.920
22.920	22.960	23.000	23.040	23.080	23.120	23.160
23.160	23.200	23.240	23.280	23.320	23.360	23.400
23.400	23.440	23.480	23.520	23.560	23.600	23.640
23.640	23.680	23.720	23.760	23.800	23.840	23.880
23.880	23.920	23.960	24.000	24.040	24.080	24.120
24.120	24.160	24.200	24.240	24.280	24.320	24.360
24.360	24.400	24.440	24.480	24.520	24.560	24.600
24.600	24.640	24.680	24.720	24.760	24.800	24.840
24.840	24.880	24.920	24.960	25.000	25.040	25.080
25.080	25.120	25.160	25.200	25.240	25.280	25.320
25.320	25.360	25.400	25.440	25.480	25.520	25.560
25.560	25.600	25.640	25.680	25.720	25.760	25.800
25.800	25.840	25.880	25.920	25.960	26.000	26.040
26.040	26.080	26.120	26.160	26.200	26.240	26.280
26.280	26.320	26.360	26.400	26.440	26.480	26.520
26.520	26.560	26.600	26.640	26.680	26.720	26.760
26.760	26.800	26.840	26.880	26.920	26.960	27.000
27.000	27.040	27.080	27.120	27.160	27.200	27.240
27.240	27.280	27.320	27.360	27.400	27.440	27.480
27.480	27.520	27.560	27.600	27.640	27.680	27.720
27.720	27.760	27.800	27.840	27.880	27.920	27.960
27.960	28.000	28.040	28.080	28.120	28.160	28.200
28.200	28.240	28.280	28.320	28.360	28.400	28.440
28.440	28.480	28.520	28.560	28.600	28.640	28.680
28.680	28.720	28.760	28.800	28.840	28.880	28.920
28.920	28.960	29.000	29.040	29.080	29.120	29.160
29.160	29.200	29.240	29.280	29.320	29.360	29.400
29.400	29.440	29.480	29.520	29.560	29.600	29.640
29.640	29.680	29.720	29.760	29.800	29.840	29.880
29.880	29.920	29.960	30.000	30.040	30.080	30.120
30.120	30.160	30.200	30.240	30.280	30.320	30.360
30.360	30.400	30.440	30.480	30.520	30.560	30.600
30.600	30.640	30.680	30.720	30.760	30.800	30.840
30.840	30.880	30.920	30.960	31.000	31.040	31.080
31.080	31.120	31.160	31.200	31.240	31.280	31.320
31.320	31.360	31.400	31.440	31.480	31.520	31.560
31.560	31.600	31.640	31.680	31.720	31.760	31.800
31.800	31.840	31.880	31.920	31.960	32.000	32.040
32.040	32.080	32.120	32.160	32.200	32.240	32.280
32.280	32.320	32.360	32.400	32.440	32.480	32.520
32.520	32.560	32.600	32.640	32.680	32.720	32.760
32.760	32.800	32.840	32.880	32.920	32.960	33.000
33.000	33.040	33.080	33.120	33.160	33.200	33.240
33.240	33.280	33.320	33.360	33.400	33.440	33.480
33.480	33.520	33.560	33.600	33.640	33.680	33.720
33.720	33.760	33.800	33.840	33.880	33.920	33.960
33.960	34.000	34.040	34.080	34.120	34.160	34.200
34.200	34.240	34.280	34.320	34.360	34.400	34.440
34.440	34.480	34.520	34.560	34.600	34.640	34.680
34.680	34.720	34.760	34.800	34.840	34.880	34.920
34.920	34.960	35.000	35.040	35.080	35.120	35.160
35.160	35.200	35.240	35.280	35.320	35.360	35.400
35.400	35.440	35.480	35.520	35.560	35.600	35.640
35.640	35.680	35.720	35.760	35.800	35.840	35.880

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						