BROOKHAVEN NATIONAL LABORATORY
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Upton, New York

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 $\sim$ 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 $\pm$ 1 mr horizontally, $\pm$ 1 mr vertically, and $\pm$ 1% $\Delta p/p$. Limiting apertures of $\pm$ 1.375 in. horizontally in Q7 and $\pm$ 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 $\pm$ 2 mr horizontally and $\pm$ 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. tungston 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		
	D5	B	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		as required		
	D5	B	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		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)	± 0.60 x ± 0.55	± 0.70 x ± 0.60	± 1.2 x ± 0.95	± 1.8 x ± 4.9	± 1.2 x ± 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%

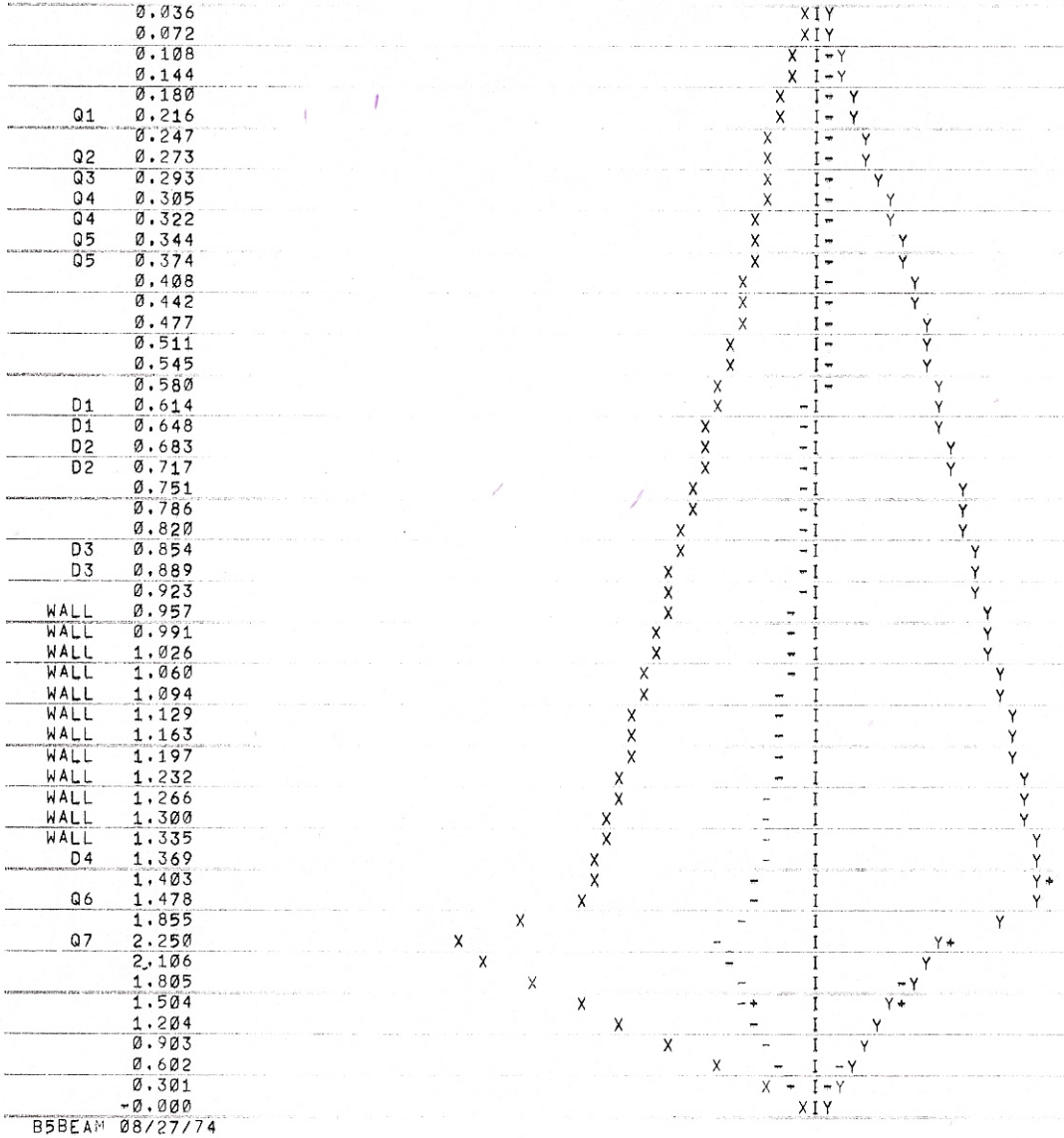
TABLE III

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	A	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
4.000	0.001Ø0	4.000	0.00100	28.500	0.010
	1 mr		1 mr		1 %



	0.036	0.036	
	0.072	0.072	
	0.108	0.108	
	0.144	0.144	
	0.180	0.180	
Q1	0.216	0.216	Q1
	0.247	0.256	
Q2	0.273	0.303	Q2
Q3	0.293	0.356	Q3
Q4	0.305	0.418	Q4
Q4	0.322	0.474	Q4
Q5	0.344	0.521	Q5
Q5	0.374	0.558	Q5
	0.408	0.588	
	0.442	0.617	
	0.477	0.647	
	0.511	0.677	
	0.545	0.706	
	0.580	0.736	
D1	0.614	0.765	D1
D1	0.648	0.795	D1
D2	0.683	0.824	D2
D2	0.717	0.854	D2
	0.751	0.883	
	0.786	0.913	
	0.820	0.942	
D3	0.854	0.972	D3
D3	0.889	1.001	D3
	0.923	1.030	
WALL	0.957	1.060	WALL
WALL	0.991	1.089	WALL
WALL	1.026	1.118	WALL
WALL	1.060	1.147	WALL
WALL	1.094	1.176	WALL
WALL	1.129	1.206	WALL
WALL	1.163	1.235	WALL
WALL	1.197	1.264	WALL
WALL	1.232	1.293	WALL
WALL	1.266	1.322	WALL
WALL	1.300	1.351	WALL
WALL	1.335	1.381	WALL
D4	1.369	1.410	D4
	1.403	1.439	
Q6	1.478	1.427	Q6
	1.855	1.132	
Q7	2.250	0.799	Q7
	2.106	0.655	
	1.805	0.562	
	1.504	0.468	
	1.204	0.374	
	0.903	0.281	
	0.602	0.187	
	0.301	0.094	
	-0.000	0.000	

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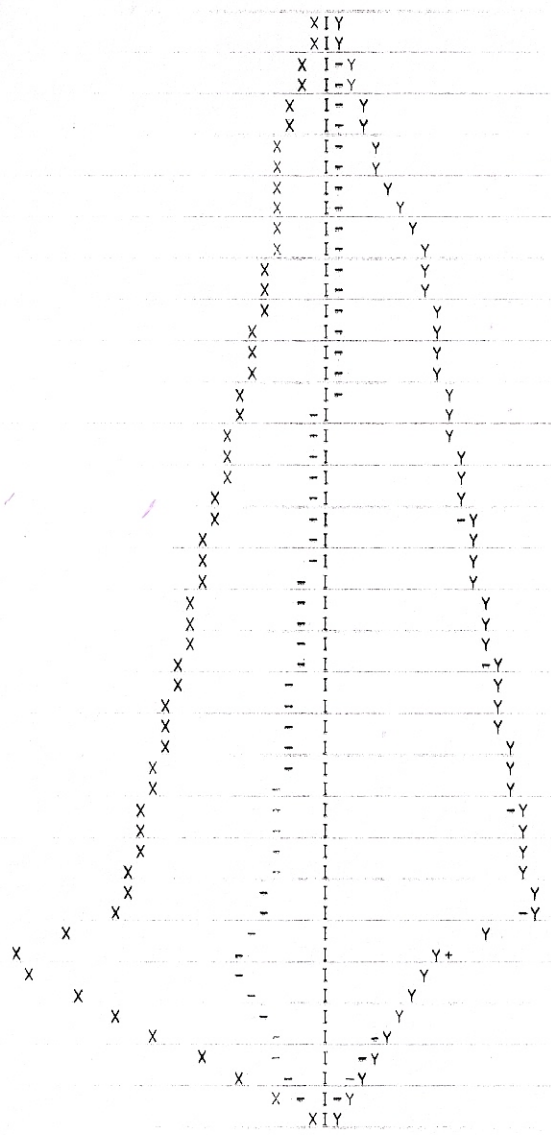
Figure 1. B5 with B1 at 8GeV/c

XMAX	DX1	YMAX	DY1	P	DP
4.000	0.001 0	4.000	0.00100	28.500	0.010
	1 mr		1 mr		1 %



	0.036	0.036	
	0.072	0.072	
	0.108	0.108	
	0.144	0.144	
	0.180	0.180	
Q1	0.216	0.216	Q1
	0.245	0.259	
Q2	0.266	0.310	Q2
Q3	0.277	0.373	Q3
Q4	0.279	0.448	Q4
Q4	0.286	0.515	Q4
Q5	0.302	0.567	Q5
Q5	0.326	0.602	Q5
	0.356	0.625	
	0.387	0.649	
	0.418	0.672	
	0.448	0.695	
	0.479	0.718	
	0.509	0.742	
D1	0.540	0.765	D1
D1	0.571	0.788	D1
D2	0.601	0.811	D2
D2	0.632	0.834	D2
	0.662	0.858	
	0.693	0.881	
	0.723	0.904	
D3	0.754	0.927	D3
D3	0.785	0.950	D3
	0.815	0.973	
WALL	0.846	0.996	WALL
WALL	0.876	1.019	WALL
WALL	0.907	1.042	WALL
WALL	0.938	1.065	WALL
WALL	0.968	1.088	WALL
WALL	0.999	1.111	WALL
WALL	1.029	1.134	WALL
WALL	1.060	1.157	WALL
WALL	1.090	1.180	WALL
WALL	1.121	1.203	WALL
WALL	1.152	1.226	WALL
WALL	1.182	1.249	WALL
D4	1.213	1.272	D4
	1.243	1.295	
Q6	1.310	1.282	Q6
	1.640	1.017	
Q7	1.987	0.718	Q7
	1.859	0.589	
	1.593	0.505	
	1.328	0.421	
	1.062	0.337	
	0.797	0.252	
	0.531	0.168	
	0.266	0.084	
	-0.000	-0.000	

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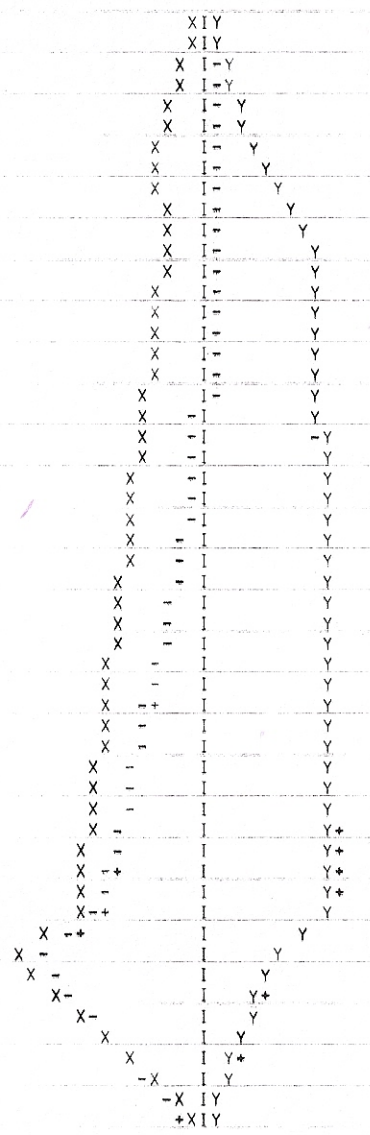
Figure 2. B5 with B1 at 12GeV/c

XMAX	DXi	YMAX	DY1	P	DP
4.000	0.001Ø0	4.000	0.00100	28.500	Ø.Ø10
	1 mr		1 mr		1 %



	Ø.Ø36	Ø.Ø36
	Ø.Ø72	Ø.Ø72
	Ø.1Ø8	Ø.1Ø8
	Ø.144	Ø.144
	Ø.18Ø	Ø.18Ø
Q1	Ø.216	Ø.216 Q1
	Ø.24Ø	Ø.263
Q2	Ø.252	Ø.326 Q2
Q3	Ø.248	Ø.4Ø7 Q3
Q4	Ø.23Ø	Ø.512 Q4
Q4	Ø.219	Ø.6ØØ Q4
Q5	Ø.218	Ø.66Ø Q5
Q5	Ø.228	Ø.686 Q5
	Ø.246	Ø.691
	Ø.263	Ø.695
	Ø.281	Ø.699
	Ø.299	Ø.7Ø3
	Ø.316	Ø.7Ø8
	Ø.334	Ø.712
D1	Ø.351	Ø.716 D1
D1	Ø.369	Ø.72Ø D1
D2	Ø.386	Ø.724 D2
D2	Ø.4Ø4	Ø.728 D2
	Ø.422	Ø.732
	Ø.439	Ø.735
	Ø.457	Ø.739
D3	Ø.474	Ø.743 D3
D3	Ø.492	Ø.746 D3
	Ø.5Ø9	Ø.75Ø
WALL	Ø.527	Ø.753 WALL
WALL	Ø.545	Ø.757 WALL
WALL	Ø.562	Ø.76Ø WALL
WALL	Ø.58Ø	Ø.764 WALL
WALL	Ø.597	Ø.767 WALL
WALL	Ø.615	Ø.771 WALL
WALL	Ø.632	Ø.774 WALL
WALL	Ø.65Ø	Ø.778 WALL
WALL	Ø.668	Ø.781 WALL
WALL	Ø.685	Ø.784 WALL
WALL	Ø.7Ø3	Ø.788 WALL
WALL	Ø.72Ø	Ø.791 WALL
D4	Ø.738	Ø.795 D4
	Ø.755	Ø.798
Q6	Ø.793	Ø.781 Q6
	Ø.981	Ø.62Ø
Q7	1.177	Ø.44Ø Q7
	1.1ØØ	Ø.362
	Ø.942	Ø.31Ø
	Ø.785	Ø.258
	Ø.628	Ø.2Ø7
	Ø.471	Ø.155
	Ø.314	Ø.1Ø3
	Ø.157	Ø.Ø52
	-Ø.ØØØ	-Ø.ØØØ

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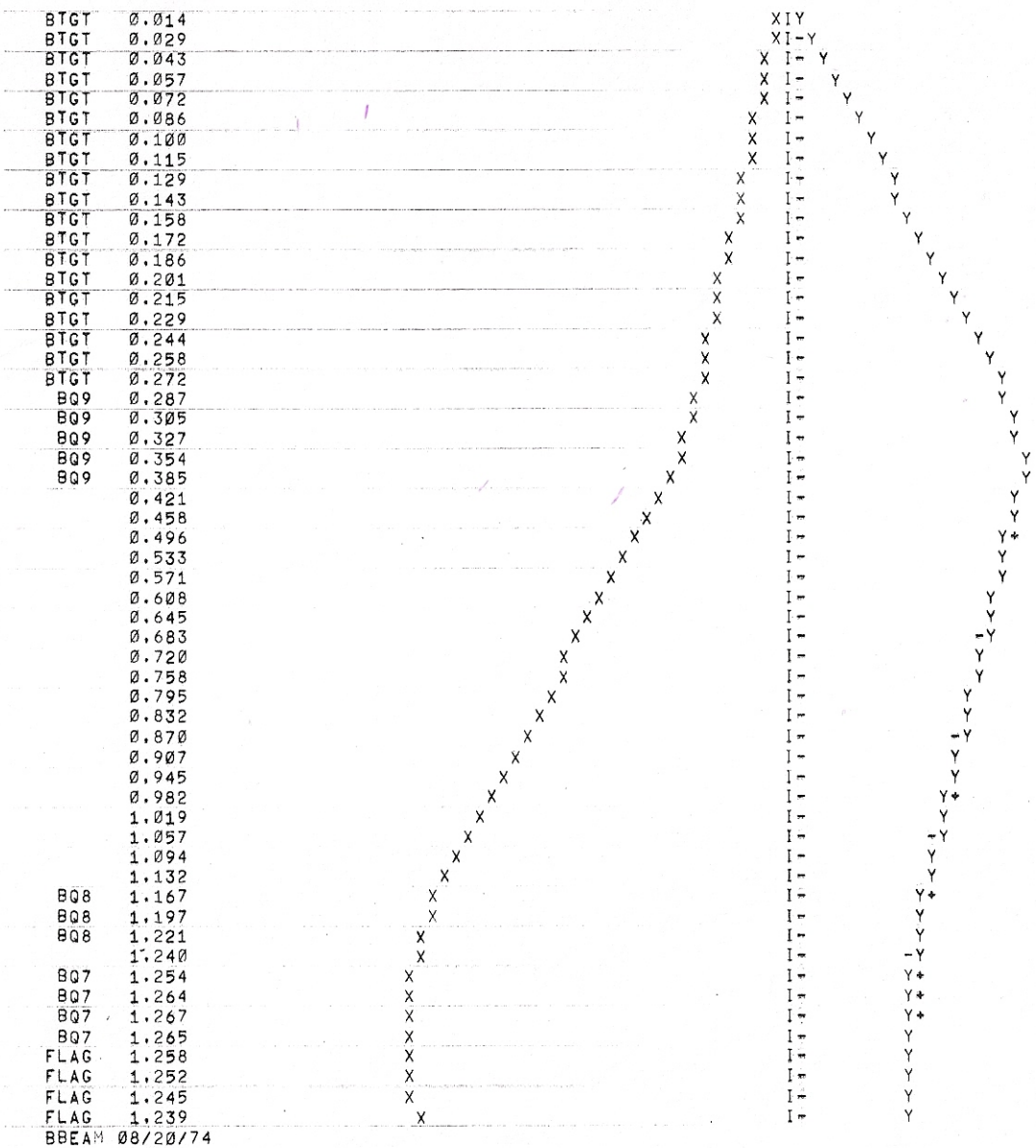
Figure 3. B5 with B1 at 20GeV/c

XMAX	DX1	YMAX	DY1	P	DP
2.000	0.00200	2.000	0.00500	28.500	0.010
	2 mr		5 mr		1 %



BTGT	0.014		0.036	BTGT
BTGT	0.029		0.072	BTGT
BTGT	0.043		0.108	BTGT
BTGT	0.057		0.143	BTGT
BTGT	0.072		0.179	BTGT
BTGT	0.086		0.215	BTGT
BTGT	0.100		0.251	BTGT
BTGT	0.115		0.287	BTGT
BTGT	0.129		0.323	BTGT
BTGT	0.143		0.359	BTGT
BTGT	0.158		0.394	BTGT
BTGT	0.172		0.430	BTGT
BTGT	0.186		0.466	BTGT
BTGT	0.201		0.502	BTGT
BTGT	0.215		0.538	BTGT
BTGT	0.229		0.574	BTGT
BTGT	0.244		0.609	BTGT
BTGT	0.258		0.645	BTGT
BTGT	0.272		0.681	BTGT
BQ9	0.287		0.716	BQ9
BQ9	0.305		0.743	BQ9
BQ9	0.327		0.759	BQ9
BQ9	0.354		0.766	BQ9
BQ9	0.385		0.763	BQ9
	0.421		0.750	
	0.458		0.734	
	0.496		0.718	
	0.533		0.703	
	0.571		0.687	
	0.608		0.671	
	0.645		0.656	
	0.683		0.640	
	0.720		0.624	
	0.758		0.609	
	0.795		0.593	
	0.832		0.577	
	0.870		0.562	
	0.907		0.546	
	0.945		0.530	
	0.982		0.515	
	1.019		0.499	
	1.057		0.483	
	1.094		0.468	
	1.132		0.452	
BQ8	1.167		0.437	BQ8
BQ8	1.197		0.424	BQ8
BQ8	1.221		0.413	BQ8
	1.240		0.405	
BQ7	1.254		0.397	BQ7
BQ7	1.264		0.391	BQ7
BQ7	1.267		0.387	BQ7
BQ7	1.265		0.385	BQ7
FLAG	1.258		0.383	FLAG
FLAG	1.252		0.382	FLAG
FLAG	1.245		0.381	FLAG
FLAG	1.239		0.380	FLAG

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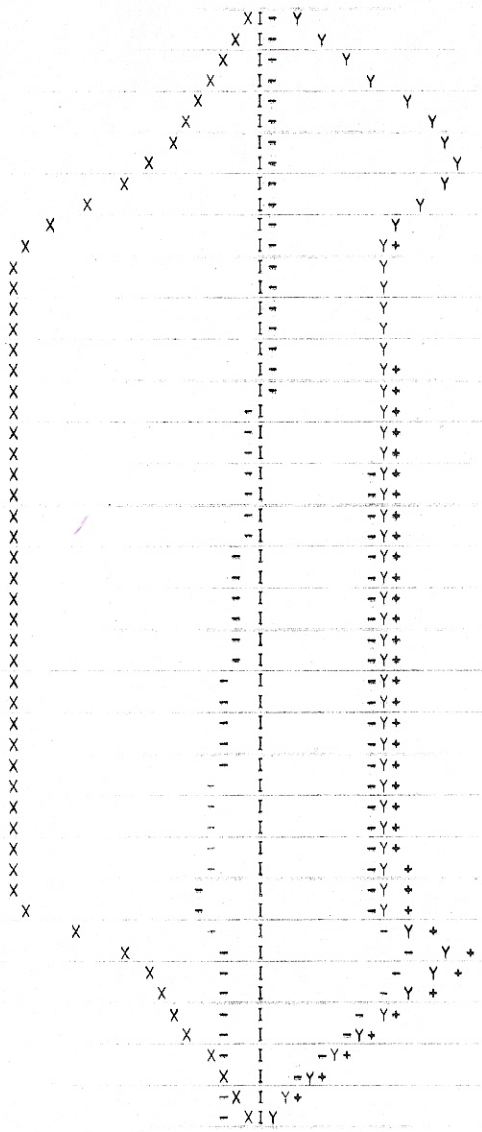
Figure 4. Ray trace from B target to upstream flag

XMAX	DX1	YMAX	DY1	P	DP
4.000	0.00200	4.000	0.00500	28.500	0.010
	2 mr		5 mr		1 %



	X	Y	
	0.072	0.180	
	0.144	0.360	
	0.216	0.540	
	0.288	0.719	
	0.360	0.899	
Q1	0.432	1.078	Q1
	0.533	1.186	
Q2	0.673	1.210	Q2
Q3	0.863	1.143	Q3
Q4	1.116	0.991	Q4
Q4	1.330	0.868	Q4
Q5	1.470	0.795	Q5
Q5	1.526	0.766	Q5
	1.526	0.767	
	1.526	0.767	
	1.526	0.767	
	1.526	0.768	
	1.526	0.768	
	1.526	0.768	
D1	1.526	0.769	D1
D1	1.526	0.769	D1
D2	1.526	0.769	D2
D2	1.526	0.769	D2
	1.526	0.769	
	1.526	0.769	
	1.526	0.769	
D3	1.526	0.769	D3
Q3	1.526	0.769	D3
	1.526	0.769	
WALL	1.526	0.769	WALL
WALL	1.526	0.769	WALL
WALL	1.526	0.769	WALL
WALL	1.526	0.769	WALL
WALL	1.526	0.769	WALL
WALL	1.526	0.769	WALL
WALL	1.526	0.769	WALL
WALL	1.526	0.769	WALL
WALL	1.526	0.769	WALL
WALL	1.526	0.770	WALL
WALL	1.526	0.770	WALL
WALL	1.526	0.770	WALL
D4	1.526	0.770	D4
	1.526	0.770	
Q6	1.487	0.789	Q6
	1.186	0.952	
Q7	0.850	1.124	Q7
	0.700	1.047	
	0.600	0.897	
	0.500	0.748	
	0.400	0.598	
	0.300	0.449	
	0.200	0.299	
	0.100	0.150	
	0.000	0.000	

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Figure 5. B5 exclusively with D1 ramped