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E781 Hyperon Beam and Targeting System

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The E781 beamline included a set of dipole magnets that directed the 800 GeV/c proton beam from the Tevatron onto a target just inside the aperture of the Hyperon magnet as shown in Figure 1. This figure is a plan view in PC3 (at the vertical y-axis =0) of the apparatus with the z-axis origin at the upstream face of the hyperon magnet and the x–axis origin at the nominal center of the proton beam. Note the differing units of the two axes.

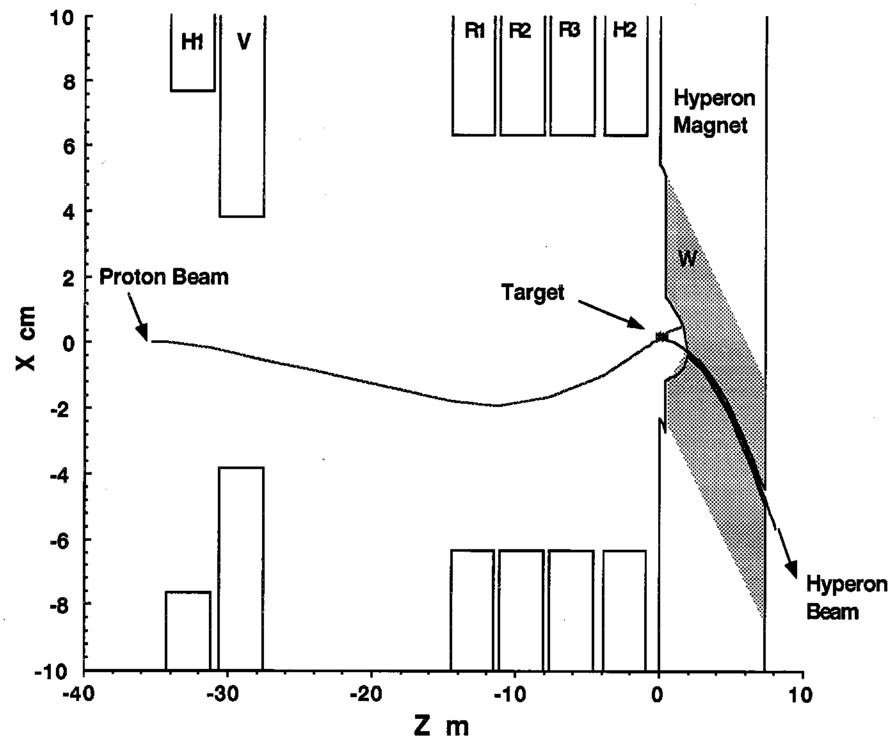

Figure 1
The E781 beam and targeting system

The Hyperon Magnet was located in the upstream region of the Proton Laboratory enclosure PC4. The targeting magnets, H1, V, R1-3, and H2 were in the PC3 enclosure. Focussing quadrupole magnets (not shown) were upstream of these magnets also in PC3. They served to focus the proton beam on the target shown in Figure 1. See H-808 for a description of the targets. Hyperons (and other particles) were produced in this target; collimated by the tungsten (W) channel inserts, and deflected by the magnetic field to form the Hyperon Beam, which is shown exiting the Hyperon magnet in PC4.

The magnets H1 and V were standard Fermilab dipole magnets (type 6-3-120). Magnets R1-3 and H2 were standard Fermilab 'EPB' dipoles (type 5-1.5.120). Fermilab TM-632 describes their physical and electrical properties. Note that the Hyperon Magnet is rotated by 8.85 mrad relative to the PC3 center line as indicated in Figure 1. The Hyperon Magnet is a special high field magnet constructed for the Fermilab Proton Center charged hyperon program. Detailed magnetic field measurements were made for the Hyperon Magnet (see H-763)

The configuration of sintered tungsten blocks (see Table 1) forming the hyperon channel is shown in Figure 2 for the horizontal plane and Figure 3 for the vertical plane.

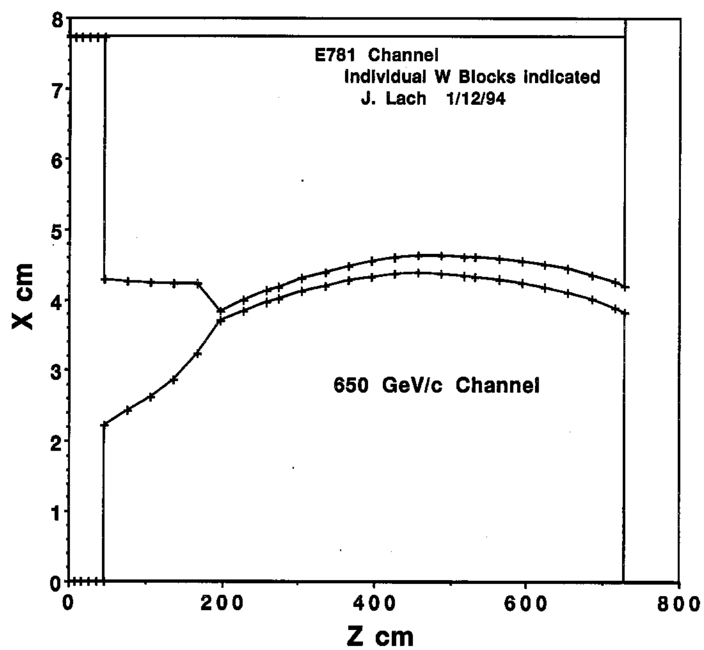

Figure 2
The Hyperon Magnet horizontal apertures

The magnets H1, R1-3, and H2 could deflect the proton beam in the horizontal (x-z) plane and magnet V could deflect the protons in the vertical (y-z) plane. The purpose of V was to center the protons vertically on the target. However the horizontal magnets could deflect the proton beam so as to change the horizontal production angle of the hyperons. The proton beam central ray at the target and the central ray (also at the target) of the beam exiting the Hyperon Magnet channel define this production angle. Figure 1 depicts the 800 GeV/c proton beam being deflected so as to produce a +4 mrad positive hyperon beam. The trajectories of the central rays in Figure 1 are calculated for these particular targeting conditions and include the significant effects of the Hyperon Magnet fringe field (see H-808).

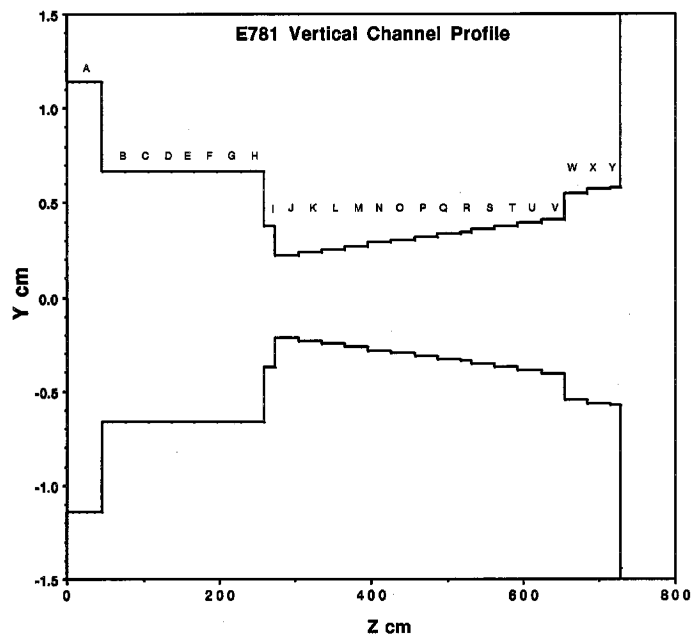

Figure 3
The Hyperon Magnet vertical apertures
The letters refer to the individual blocks

The magnets R1, R2, and R3 are connected in series and powered by a single supply. All of the other targeting magnets have individual power supplies. The Hyperon Magnet 's current was set to 3250 amps (near the maximum value of 3600 amps and 35 kG magnetic field) to transport a –650 GeV/c central ray. For most of the experiment the beam was run at 0-mrad production and –650 GeV/c. Changing the polarity and current in the Hyperon Magnet allowed for changes in particle charge and momenta. However in the positive configuration safety considerations required the maximum momentum be constrained to be below 572 GeV/c and the targeting angle be greater than 2 mrad in absolute value. Table 2 show magnet currents and running conditions used for typical runs.

The Tevatron external proton beam was contained in an approximately 23 s pulse within a 60 s accelerator cycle time. Beam intensities incident on the production target could be as high as 2 10^{12} protons per pulse in the negative configuration but much less in the positive configuration. The proton beam rate was constrained by radiation safety considerations, limitation of the hyperon beam rate to about 10^6 particles per second, and the need to keep the experiment trigger rate to a tractable level.

Table 1 Hyperon Magnet Tungsten block dimensions										
Block Name	Number Required		X Inches			Y Inches			Z Inches	
			+	-		+	-			
B1	2	2.5400	0.0000	0.0050	0.1890	0.0000	0.0050	12.0000	±	0.0050
B2	1	3.2900	0.0100	0.0100	0.5220	0.0000	0.0050	12.0000	±	0.0050
C1	2	2.5400	0.0000	0.0050	0.1890	0.0000	0.0050	12.0000	±	0.0050
C2	1	3.2900	0.0100	0.0100	0.5220	0.0000	0.0050	12.0000	±	0.0050
D1	2	2.5400	0.0000	0.0050	0.1890	0.0000	0.0050	12.0000	±	0.0050
D2	1	3.2900	0.0100	0.0100	0.5220	0.0000	0.0050	12.0000	±	0.0050
E1	2	2.5400	0.0000	0.0050	0.1890	0.0000	0.0050	12.0000	±	0.0050
E2	1	3.2900	0.0100	0.0100	0.5220	0.0000	0.0050	12.0000	±	0.0050
F1	2	2.5400	0.0000	0.0050	0.1890	0.0000	0.0050	12.0000	±	0.0050
F2	1	3.2900	0.0100	0.0100	0.5220	0.0000	0.0050	12.0000	±	0.0050
G1	2	2.5400	0.0000	0.0050	0.1890	0.0000	0.0050	12.0000	±	0.0050
G2	1	3.2900	0.0100	0.0100	0.5220	0.0000	0.0050	12.0000	±	0.0050
H1	2	2.5400	0.0000	0.0050	0.1890	0.0000	0.0050	12.0000	±	0.0050
H2	1	3.2900	0.0100	0.0100	0.5220	0.0000	0.0050	12.0000	±	0.0050
I1	2									
I2	1	3.2900	0.0100	0.0100	0.2960	0.0000	0.0050	6.0000	±	0.0050
J1	2									
J2	1	3.2900	0.0100	0.0100	0.1700	0.0000	0.0050	12.0000	±	0.0050
K1	2									
K2	1	3.2900	0.0100	0.0100	0.1840	0.0000	0.0050	12.0000	±	0.0050
L1	2	3.0400	0.0000	0.0050	0.3520	0.0000	0.0050	12.0000	±	0.0050
L2	1	3.2900	0.0100	0.0100	0.1960	0.0000	0.0050	12.0000	±	0.0050
M1	2	3.0400	0.0000	0.0050	0.3450	0.0000	0.0050	12.0000	±	0.0050
M2	1	3.2900	0.0100	0.0100	0.2100	0.0000	0.0050	12.0000	±	0.0050
N1	2	3.0400	0.0000	0.0050	0.3380	0.0000	0.0050	12.0000	±	0.0050
N2	1	3.2900	0.0100	0.0100	0.2240	0.0000	0.0050	12.0000	±	0.0050
O1	2	3.0400	0.0000	0.0050	0.3320	0.0000	0.0050	12.0000	±	0.0050
O2	1	3.2900	0.0100	0.0100	0.2360	0.0000	0.0050	12.0000	±	0.0050
P1	2	3.0400	0.0000	0.0050	0.3250	0.0000	0.0050	12.0000	±	0.0050
P2	1	3.2900	0.0100	0.0100	0.2500	0.0000	0.0050	12.0000	±	0.0050
Q1	2	3.0400	0.0000	0.0050	0.3190	0.0000	0.0050	12.0000	±	0.0050
Q2	1	3.2900	0.0100	0.0100	0.2620	0.0000	0.0050	12.0000	±	0.0050
R1	2	3.0400	0.0000	0.0050	0.3160	0.0000	0.0050	6.0000	±	0.0050
R2	1	3.2900	0.0100	0.0100	0.2680	0.0000	0.0050	6.0000	±	0.0050
S1	2	3.0400	0.0000	0.0050	0.3090	0.0000	0.0050	12.0000	±	0.0050
S2	1	3.2900	0.0100	0.0100	0.2820	0.0000	0.0050	12.0000	±	0.0050
T1	2	3.0400	0.0000	0.0050	0.3020	0.0000	0.0050	12.0000	±	0.0050
T2	1	3.2900	0.0100	0.0100	0.2960	0.0000	0.0050	12.0000	±	0.0050
U1	2	3.0400	0.0000	0.0050	0.2960	0.0000	0.0050	12.0000	±	0.0050
U2	1	3.2900	0.0100	0.0100	0.3080	0.0000	0.0050	12.0000	±	0.0050
V1	2	3.0400	0.0000	0.0050	0.2890	0.0000	0.0050	12.0000	±	0.0050
V2	1	3.2900	0.0100	0.0100	0.3220	0.0000	0.0050	12.0000	±	0.0050
W1	2	3.0400	0.0000	0.0050	0.2330	0.0000	0.0050	12.0000	±	0.0050
W2	1	3.2900	0.0100	0.0100	0.4340	0.0000	0.0050	12.0000	±	0.0050
X1	2	3.0400	0.0000	0.0050	0.2260	0.0000	0.0050	12.0000	±	0.0050
X2	1	3.2900	0.0100	0.0100	0.4480	0.0000	0.0050	12.0000	±	0.0050
Y1	2	3.0400	0.0000	0.0050	0.2230	0.0000	0.0050	6.0000	±	0.0050
Y2	1	3.2900	0.0100	0.0100	0.4540	0.0000	0.0050	6.0000	±	0.0050
Fabrication is to do done with tungsten (Densalloy 18) of density 18.0g/cc non-magnetic (0.65 lbs/cubic inches)										

Table 2 Angle and Momentum Run Summary

Mom GeV/c	TGT Ang m r	PC3tgt	PC3ANA amps	PC3V amps	PC3H2 amps	PC3BR amps	PC3H1 calc amps	PC3H1 meas amps	Run	Events	Log	Histg?	Comments
-650	0.00	22334	-3250	160.0	872.0	0.0	-69.0	-66.0			ML2/248		
-650	0.00	22334	-3250	130.0	872.0	0.0	-69.0	-66.0			ML3/8		
-650	0.00	22334	-3250	140.0	872.0	0.0	-69.0	-87.0			ML3/65		
-650	0.00	22334	-3250	140.0	872.0	0.0	-69.0	-63.0			ML3/108		
-650	0.00	22334?	-3250	140.0	872.0	0.0	-69.0	-63.0	2697	1.06E+06	ML3/109	Yes	
-650	0.00	?	-3250	140.0	872.0	0.0	-69.0	-63.0	2698	2.20E+04	ML3/110	No	
-650	0.00	22334	-3250	130.0	872.0	0.0	-69.0	-84.0	3123	1.00E+06	ML3/216	Yes	
-650	0.00	0	-3250	140.0	872.0	0.0	-69.0	-63.0	3124	1.30E+05	ML3/216	Yes	
-650	0.00		-3250	77.0	872.0	0.0	-69.0	-88.0			ML3/259		
-650	0.00	22334	-3250	70.0	872.0	0.0	-69.0	-75.0	6142		ML5/73	Yes	M1 off
-650	0.00	10424	-3250	70.0	872.0	0.0	-69.0	-75.0	6143		ML5/74	Yes	M1 off
-650	0.00	10424	-3250	70.0	872.0	0.0	-69.0	-75.0	6144		ML5/76	Yes	M1-M3 off
-650	0.00	22334	-3250	70.0	872.0	0.0	-69.0	-75.0	6145		ML5/76	Yes	M1-M3 off
-650	0.00	22334	-3250	70.0	872.0	0.0	-69.0	-75.0	6146		ML5/76	Yes	M1-M3 ON
-650	-1.00	22334	-3250	140.0	0.0	765.2	-436.2	-436.0	2699	1.06E+06	ML3/111	Yes	
-650	1.00	22334	-3250	140.0	0.0	-7.4	-22.1	-6.0	2701	6.00E+05	ML3/113	Yes	Lost tape rite
-650	1.00	22334	-3250	100.0	0.0	-7.4	-22.1	-30.0	3748	1.00E+06	ML4/13	Yes	
-650	1.00	0	-3250	100.0	0.0	-7.4	-22.1	-30.0	3749	1.00E+05	ML4/13	Yes	
-650	-2.00	22334	-3250	140.0	0.0	1211.2	-657.7	-677.0	2700	1.12E+06	ML3/111	Yes	
-650	2.00	22334	-3250	120.0	0.0	-411.3	193.6	184.0	3080	1.00E+06	ML3/201	Yes	Lost tape rite
-650	2.00	0	-3250	120.0	0.0	-411.3	193.6	184.0	3081	6.20E+04	ML3/201	Yes	Lost tape rite
-650	2.00	22334	-3250	105.0	0.0	-411.3	193.6	185.0			ML4/30		
-650	-2.50	22334	-3250	140.0	0.0	1526.6	-790.3						
-650	-3.00	22334	-3250	0.0	0.0	1957.5	-926.7	-930			ML3/224		
-650	3.00	22334	-3250	145.0	0.0	-784.1	388.6	408.0	2852	4.90E+05	ML3/156	Yes	Lost tape rite
-650	-4.00	22334	-3250	0.0	1000.0	1848.4	-967.8				ML3/258		low rate
-650	4.00	22334	-3250	145.0	0.0	-1226.3	603.6	630.0	2853		ML3/158	Yes	Lost tape rite
-650	4.00	22334	-3250	120.0	0.0	-1226.3	603.6	605.0	3084	1.01E+06	ML3/204	Yes	
-650	-4.50	22334	-3250		1500.0	2006.6	-1045.5						
572	-2.00	22334	1785	162.0	0.0	1145.5	-628.2				ML7/41		Forbidden region
572	-3.00	22334	1785	162.0	751.4	1200.0	-696.1				ML7/44		Forbidden region
572	-3.50	22334	1785		800.0	1474.0	-820.0						
572	-3.75	22334	1785		800.0	1648.0	-888.0						
572	-4.00	10424	1785	155.0	800.0	1882.0	-966.0	-980.0	8818	1.00E+06	ML7/134		M1 off, Cu tgt
572	-4.00	22334	1785	155.0	800.0	1882.0	-966.0	-992.0	8819	1.00E+06	ML7/135		M1 off, Be tgt
572	-4.00	22334	1785	155.0	800.0	1882.0	-966.0	-992.0	8819	5.00E+04	ML7/136		charm tgt in
572	-4.25	22334	1785		1039.0	1900.0	-988.0						
572	-4.50	22334	1785		1286.0	1950.0	-1020.0						
572	2.00	22334	1785	153.0	0.0	-473.4	226.4	237.0	8062	3.04E+06	ML6/25		M1 off
572	2.00	10424	1785	153.0	0.0	-473.4	226.4	237.0	8063	3.12E+06	ML6/27		M1 off
572	2.00	10424	1785	153.0	0.0	-473.4	226.4	237.0	8064	2.51E+05	ML6/28		int data, filter off
572	2.00	10424	1785	153.0	0.0	-473.4	226.4	237.0	8065	1.11E+05	ML6/28		int data, filter on
572	2.00	10424	1785	153.0	0.0	-473.4	226.4	237.0	8066	2.85E+05	ML6/28		int data, filter on
572	2.00	22334	1785	153.0	0.0	-473.4	226.4	237.0	8067	3.38E+05	ML6/28		int data, filter off
650	2.00	22334	3250		-1104.2	0.0	22.3						
650	3.00	22334	3250		-800.0	-511.3	282.6						
650	3.00	22334	3250		0.0	-859.2	429.6						
572	3.00	22334	1785	70.0	0.0	-810.0		408.0	5310	1.00E+06	ML4/258		
572	3.00	22334	1785	170.0	0.0	-810.0		417.0	7237	2.00E+06	ML5/207	Yes	M1 off
572	3.00	22334	1785	170.0	0.0	-810.0		417.0	7238	2.00E+06	ML5/207	Yes	M1 On
572	3.00	0	1785	170.0	0.0	-810.0		417.0	7240	1.38E+05	ML5/209	Yes	M1 Off
572	3.00	10424	1785	170.0	0.0	-810.0		417.0	7241	2.00E+06	ML5/209	Yes	M1 Off
572	3.00	10424	1785	170.0	0.0	-810.0		417.0	7242	1.00E+06	ML5/209	Yes	M1 On
572	3.00	10424	1785	170.0	0.0	-810.0		417.0	7243	2.63E+05	ML5/209	Yes	M1-M3 off
572	3.50	22334	1785		-800.0	-705.0	386.0						
572	3.75	22334	1785		-800.0	-797.0	483.0						
572	4.00	22334	1785	146.0	-800.0	-892.0	483.0	510.0	8816	2.96E+06	ML7/130	Yes	M1 off
572	4.00	10424	1785	146.0	-800.0	-892.0	483.0	493.0	8817	2.07E+06	ML7/133	Yes	M1 off, Cu tgt
572	4.25	22334	1785		-800.0	-1014.0	544.0						
572	4.50	22334	1785		-800.0	-1122.0	596.0						
		All of these runs are beam trigger, unless NOTED											
		PC4TGT is out for beam trigger runs unless noted											
		PC3H1 max current is 1200 amps											
		PC3BR max is 2000 amps but Leon Beverely wants to check cooling before we try it.											