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791 Primary beam

G. M. Bunce

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Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

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Alternating Gradient Synchroton Department
BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York 11973

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No. 113

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The primary beam transport is designed to give a small spot on the production target (1 mm half-width) with a variable pitch angle from 0°-4.5°. Small-aperture quads (and benders) are used, replacing a line that was designed as a large-aperture secondary beam (B1). B1 will also be rebuilt as a primary beam line for heavy ions and can run at half the primary momentum (negatives), parasitic on B5, when B5 uses protons. The pitching magnet in B5 used to steer the beam up (the first magnet in the system which gives variable pitching angle) will be an 18D36 at first. When the desired production angle for B5 is known, this magnet will be replaced. During initial tests of B5, the B1 line will be obstructed by this magnet.

I. Primary Optics

Figure 1 shows the Transport beam envelope for the final beam design. Beam is assumed held on the B-target by a servo system, as it is now. Incident beam parameters were taken from a switchyard write-up and agree with observations on B:

Transport half sizes: $x = .13$ cm $\quad y = .13$ cm $\quad \Delta p/p = .2\%$
$x' = 1$ mrad $\quad y' = 2$ mrad

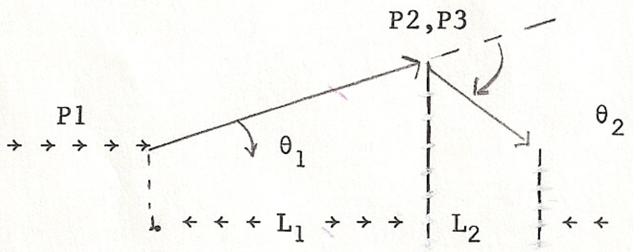
If all the beam were initially focussed on a 1-interaction length target at B, there would be approximately ± 2 mrad blow-up from multiple-scattering. The optics for this are shown in Fig. 2 (for x' = 2.3 mrad, y' = 2.8 mrad). The aperture of Q3 is marginal in Fig. 1 and too small in Fig. 2. Other tunes have been tried to squeeze the beam more, but they give a poor focus at B5.

There is no momentum recombination in the line, so D1 must be ramped ~ 1% over the spill. In addition, the horizontal tweaker just upstream of Q3 will be tied to a servo loop. At the target, without ramping, $\Delta x = .5\ \Delta p/p$ with Δx in cm and $\Delta p/p$ in percent.

Table I gives the magnet coordinates (to centers-number is reset at each bend center).

II. Variable Production Angle

The beam will be pitched up by an 18D36, then restored to the production target at a variable angle from 0° to 4.5° by two 18D72 dipoles. The three dipoles will be run in series so that small deviations in current will not affect the position of the beam at the target. Referring to the following figure,



$$y = \theta_1(L_1+L_2)-\theta_2 L_2$$

$$\Delta y = \frac{\Delta I}{I}\ (y)\quad (y \approx 0)$$

(This works perfectly if it is not necessary to shunt any current around P1, and the magnet gaps can be adjusted to come close to this condition.) If the dipoles were not in series, the required stability for each one would be 1 part in 2000.

There is no effect on Δy from $\Delta p/p$, due to the same considerations as for current variations.

The quads Q3/Q4 and tweaker (H and V) will be mounted on a platform (I-beam) which will be adjusted to center them on the selected beam line. (A few positions will be surveyed before beam is brought down.)

III. Adjustments

The horizontal tweaker will be just upstream of Q3 and will be a dynamic dipole (2" laminations) so that it can be used to servo the beam on target. At this point the beam width is $2x'_{intercept} = .15$ mrad. For a 500 amp current, $\Delta x' = 3.1$ mrad from the dipole. At the target, this is a translation of about 4 cm.

The vertical tweaker, located between Q3/4, will be capable of moving the beam by 1.5 cm at the target. ($2y'_{intercept} = .40$ mrad between Q3/4).

Figure 4 shows the field vs. current for a 3X7D22, which will be the horizontal tweaker.

IV. Instrumentation

Standard target packages (in air) will be at B and B5, with SWICs, flags, SEC, and STIC (for servoing). We will also have a flag/instrument box upstream of Q3 so that the Q1/2 focusing can be monitored, and the vertical pitch angle from P1. Loss monitors will be placed along the line.

At the target we also want a 90° monitor telescope, as is used at other target stations.

V. Servo System

I am concerned that the servo at B5 might react on "old" information due to the relative phase of the servo at the B-target. This can be avoided if one or the other has a very different response time.

Table I

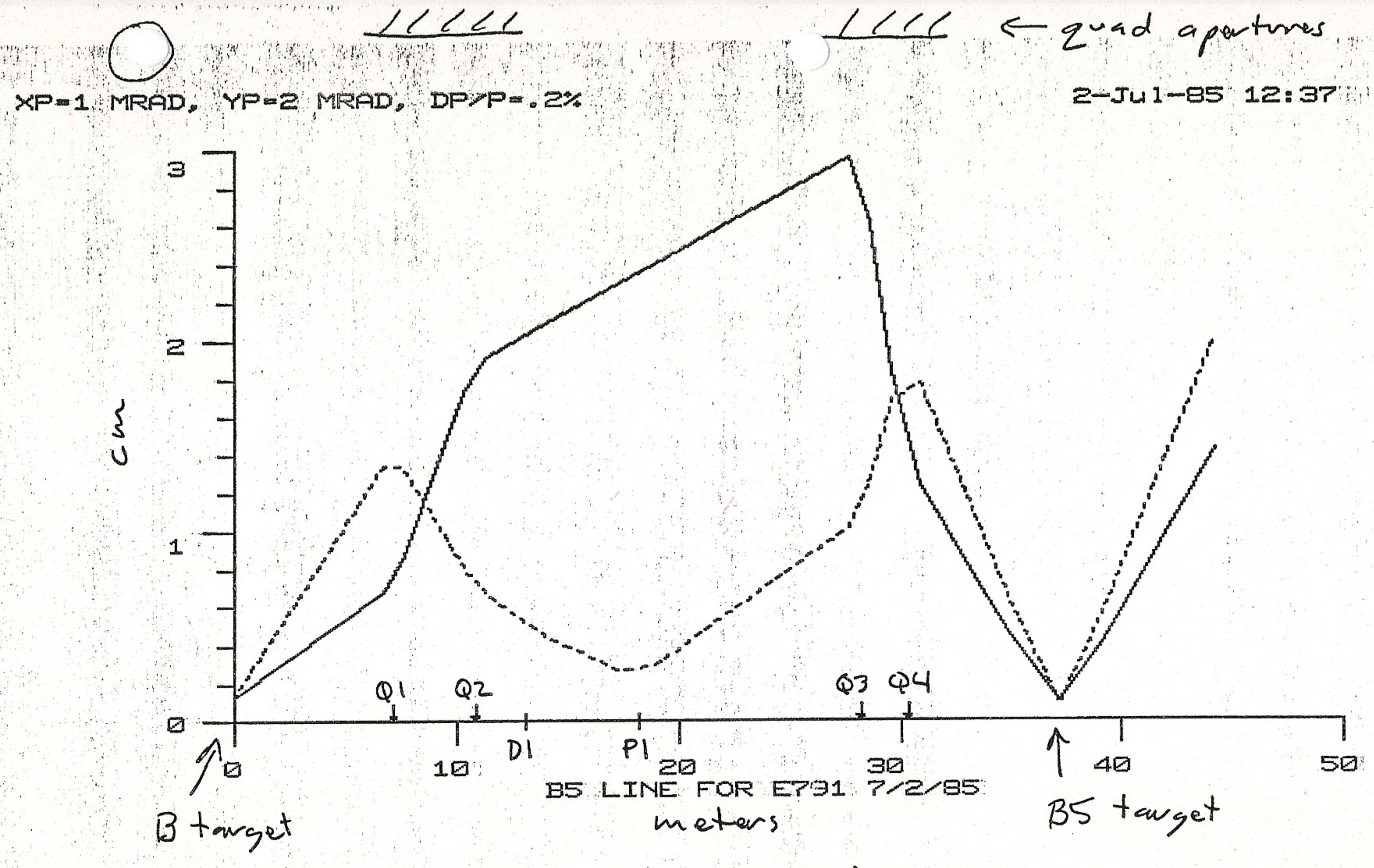
BEAM B5 EXP. NO. 791 DATE 1-30-85

REF. D'W'G. NOS. BY R.M. ORIG.

BEAM COMPONENTS					COORDINATES	
SYMBOL	TYPE	BEARING	ANGLE	DISTANCE	NORTH	EAST
"B" STATION		22.3231°	22°19'21"		14955.726	14131.549
B5BA1	Beam Abs.			219."		
B5Q1	N3Q36-12			271."		
B5Q2	N3Q36-13			413."		
B5D1	6D75-	2.07°	2°4'12"	501."		
		24.3934°	24°23'36"			
B5P1	~~8D75~~ 18D36			201."		
B5C1	ADJ.COLL.			261."		
B5D38	3x7D22-	(Hor)		550.5"		
B5Q3	N3Q36-18			595.5"		
B5P95	3x7D22-	(Vert.)		633.75"		
	different magnet?					
B5Q4	N3Q48-			672."		
B5P2	M739			757."		
B5P3	M733			853."		
B, TARGET				941."		
B5P4	18D72 MOD.			48."		
B5C2	COLL.			218.5"		
B5P5	8D92-1			321.33"		
B5D2	48D48-			811.4"		
B5D3	96D40			935.4"		

$\pi^- p \to \rho^- p$
- △ 6 GeV scaled to 10 GeV
- ▲ This expt, 10 GeV

$\pi^- p \to \pi^- p$
- ○ Owen et al.
- ● This expt, 10 GeV



(B5T1.DAT)

Figure 1a

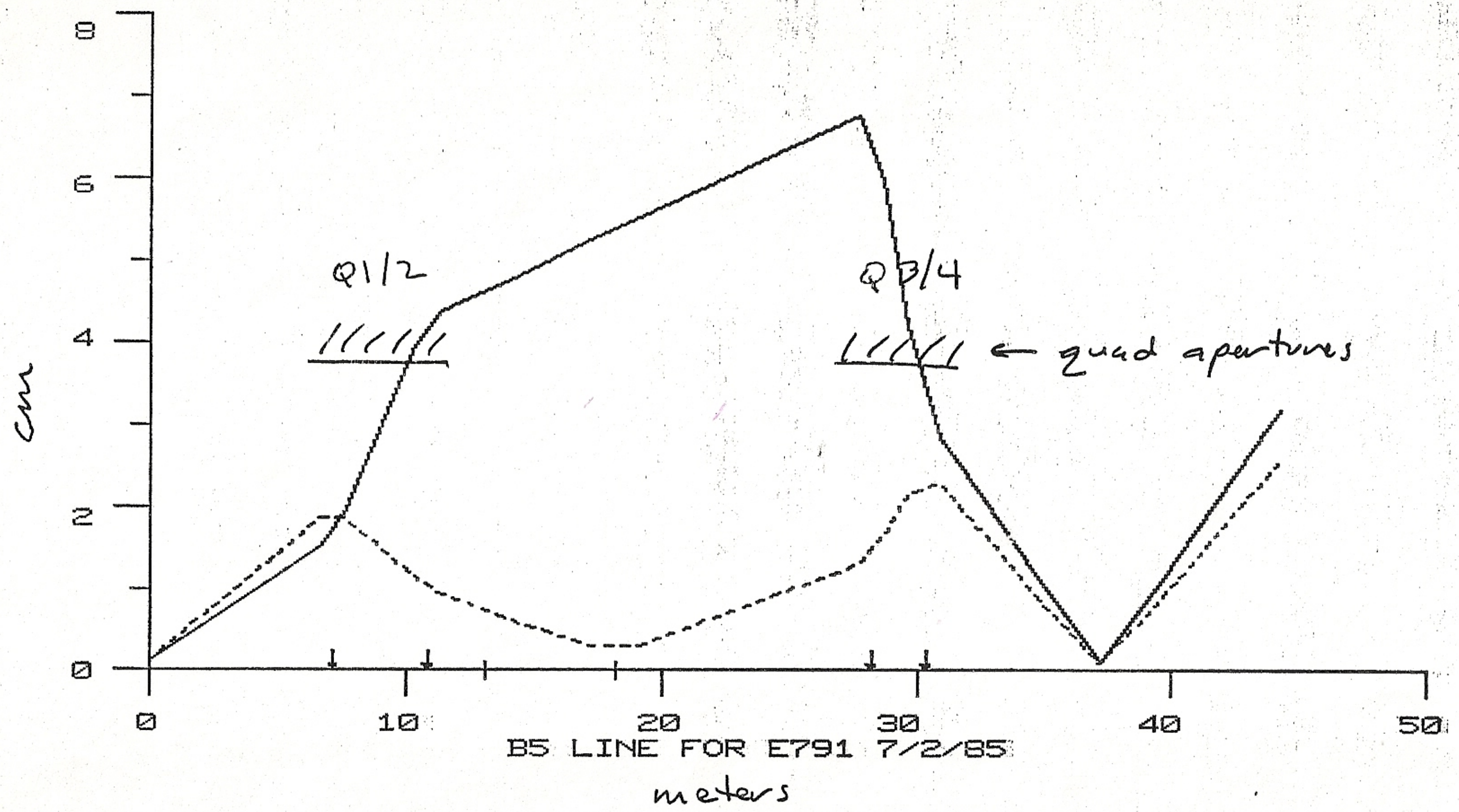
B5T1.DAT

```
"B5 LINE FOR E791 7/2/85
DRIFT   3.                 6.64000   0.00000  0.00000   0.00000
QUAD*   5.        "B5Q1    0.95000  -7.32000  2.54000  -3.31800
DRIFT   3.                 2.71000   0.00000  0.00000   0.00000
QUAD*   5.        "B5Q2    0.95000   3.50100  2.54000   7.42000
DRIFT   3.                 0.87000   0.00000  0.00000   0.00000
ROTAT   2.                 1.03500   0.00000  0.00000   0.00000
BEND*   4.        "B5D1    1.93000  17.78000  0.00000   2.06800
ROTAT   2.                 1.03500   0.00000  0.00000   0.00000
DRIFT   3.                 3.37000   0.00000  0.00000   0.00000
BEND*   4.        "B5P1    1.55000   0.00000  0.00000   0.00000
DRIFT   3.                 8.77000   0.00000  0.00000   0.00000
QUAD*   5.0 1     "B5Q3    0.95000   7.52200  2.54000   3.54200
DRIFT   3.                 1.00000   0.00000  0.00000   0.00000
QUAD*   5.0 1     "B5Q4    1.25000  -7.58900  2.54000  -2.34800
DRIFT   3.        "L9      2.00000   0.00000  0.00000   0.00000
DRIFT   3.                 2.00000   0.00000  0.00000   0.00000
DRIFT   3.                 2.24000   0.00000  0.00000   0.00000
FIT    10.                 1.00010   0.05000  0.01000   0.09860
FIT    10.                 3.00030   0.05000  0.01000   0.09130
DRIFT   3.                 2.00000   0.00000  0.00000   0.00000
DRIFT   3.                 5.00000   0.00000  0.00000   0.00000
        0.                 0.00000   0.00000  0.00000   0.00000
```

Figure 16

(2)

XP=2.3 MRAD, YP=2.8 MRAD, DP/P=.2% 2-Jul-85 12:44



XP=2.3 MRAD, YP=2.8 MRAD, DP/P=.2% 2-Jul-85 12:44

B5T2.DAT

This shows the effect of multiple scattering in the B target (1 interaction length).

Figure 2a

(2)   B5T2.[illegible]T

"B5 LINE FOR E791 7/2/85

DRIFT	3.			6.64000	0.00000	0.00000	0.00000
QUAD*	5.		"B5Q1	0.95000	-7.32000	2.54000	-3.31800
DRIFT	3.			2.71000	0.00000	0.00000	0.00000
QUAD*	5.		"B5Q2	0.95000	3.50100	2.54000	7.42000
DRIFT	3.			0.87000	0.00000	0.00000	0.00000
ROTAT	2.			1.03500	0.00000	0.00000	0.00000
BEND*	4.		"B5D1	1.93000	17.78000	0.00000	2.06800
ROTAT	2.			1.03500	0.00000	0.00000	0.00000
DRIFT	3.			3.37000	0.00000	0.00000	0.00000
BEND*	4.		"B5P1	1.55000	0.00000	0.00000	0.00000
DRIFT	3.			8.77000	0.00000	0.00000	0.00000
QUAD*	5.	0 1	"B5Q3	0.95000	7.52800	2.54000	3.53900
DRIFT	3.			1.00000	0.00000	0.00000	0.00000
QUAD*	5.	0 1	"B5Q4	1.25000	-7.62000	2.54000	-2.33700
DRIFT	3.		"L9	2.00000	0.00000	0.00000	0.00000
DRIFT	3.			2.00000	0.00000	0.00000	0.00000
DRIFT	3.			2.24000	0.00000	0.00000	0.00000
FIT	10.			1.00010	0.05000	0.01000	0.09860
FIT	10.			3.00030	0.05000	0.01000	0.10000
DRIFT	3.			2.00000	0.00000	0.00000	0.00000
DRIFT	3.			5.00000	0.00000	0.00000	0.00000
	0.			0.00000	0.00000	0.00000	0.00000

XP=2.3 MRAD, YP=2.8 MRAD, DP/P=.2%   2-Jul-85 12:44

Figure 26