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BEVALAC
EXTERNAL BEAMLINE OPTICS

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MASTER

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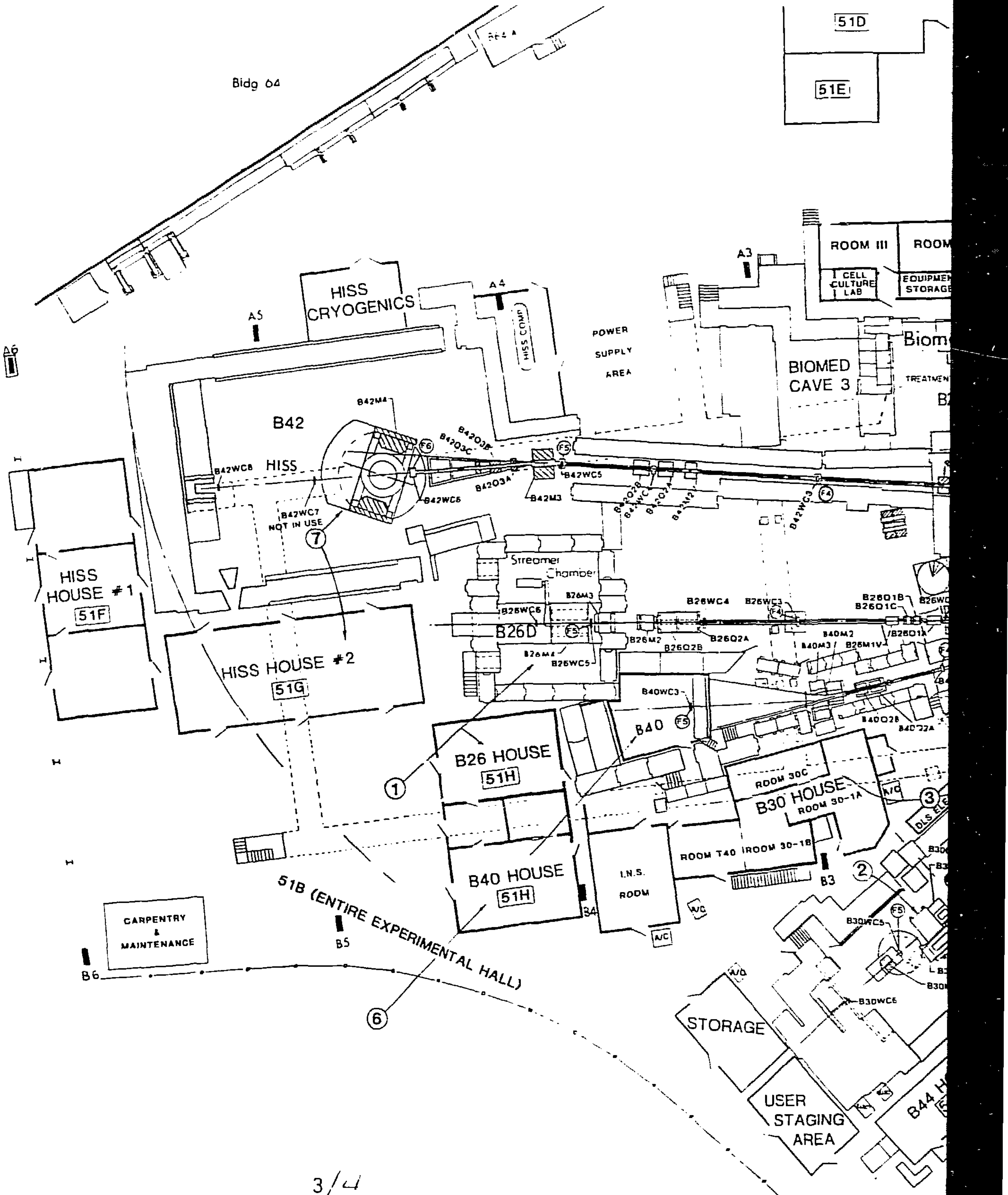
Introduction

This handbook is intended as an aid for tuning the external particle beam (EPB) lines at the Lawrence Berkeley Laboratory's Bevalac. We hope the information contained within will be useful to the Bevalac's Main Control Room and experimenters alike. First, some general information is given concerning the EPB lines and beam optics. Next, each beam line is described in detail: schematics of the beam line components are shown, all the variables required to run a beam transport program are presented, beam envelopes are given with wire chamber pictures and magnet currents, focal points and magnifications. Some preliminary scaling factors are then presented which should aid in choosing a given EPB magnet's current for a given central Bevalac field. Finally, some tuning hints are suggested.


51D
51E
Bldg 64
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A3
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POWER SUPPLY AREA
ROOM III
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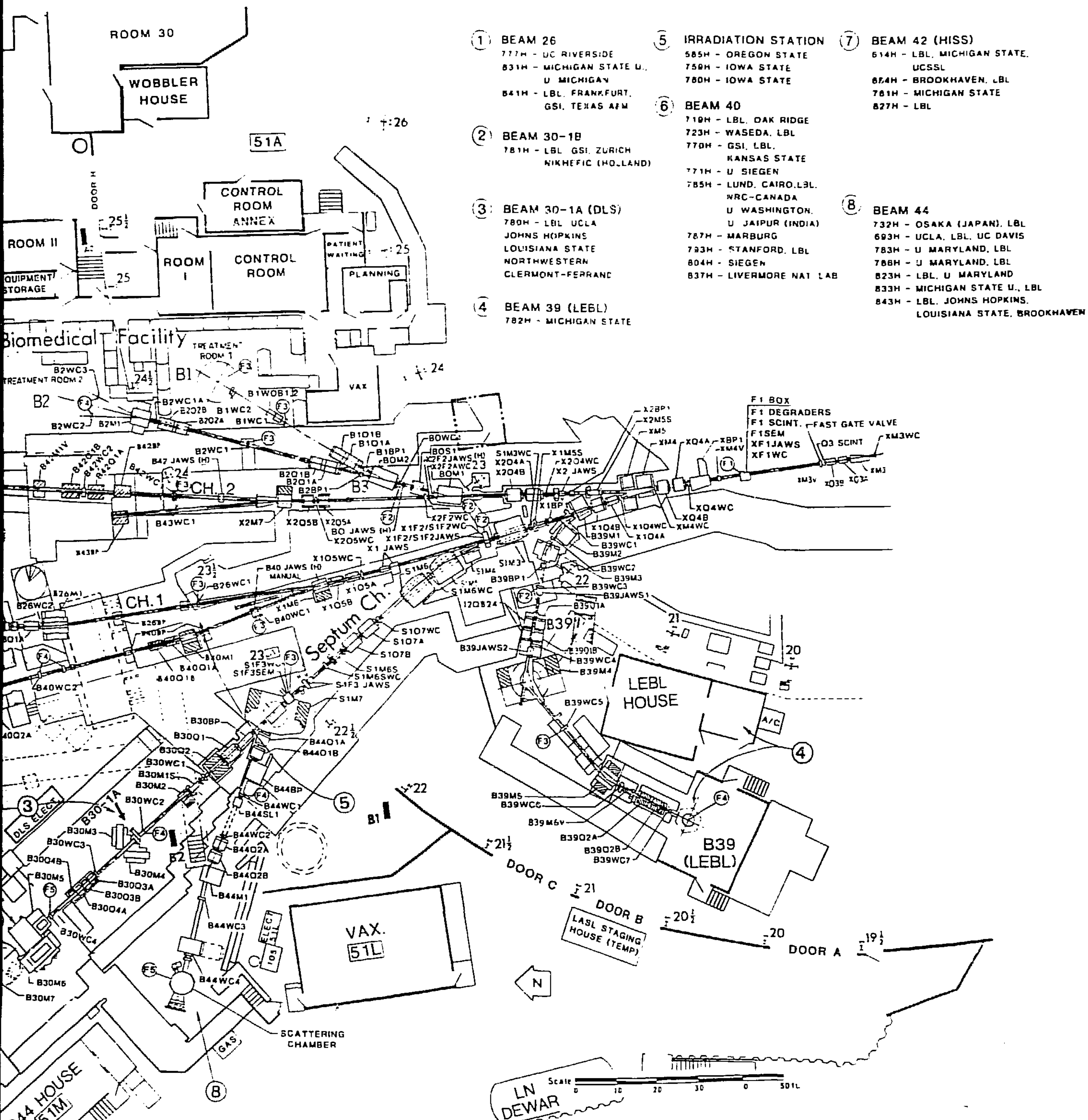

BEVATRON/BEVALAC EXPERIMENTAL STATUS MAY '87

REIMERS
19F5545

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2.1 Some Bevalac Ions and Intensities

Bevalac Particle Inventory**
August, 1985

Ion	Atomic Weight A	Atomic Number Z	Accel. Charge	Max. Energy MeV/amu	Intensity, particles/pulse, @ F1
Hydrogen	1	1	1	4900	2×10^{9}
	2	1	1	2100	1×10^{9}
Deuterons	2	1	1	2100	1×10^{5}*
Helium	3	2	2	3010	3×10^{8}
	4	2	2	2100	1×10^{10}
Boron	11	5	5	1840	1×10^{9}
Carbon	12	6	6	2100	5×10^{9}
Nitrogen	14	7	7	2100	1×10^{5}*
Oxygen	16	8	8	2100	6×10^{9}
Fluorine	19	9	9	1950	1×10^{8}
Neon	20	12	10	2100	1×10^{10}
Magnesium	24	12	12	2100	1×10^{7}*
Aluminum	27	13	13	2000	5×10^{8}
Silicon	28	14	14	2100	8×10^{8}
Argon	40	18	18	1815	1×10^{9}
Calcium	40	20	20	2100	4×10^{7}
	48	20	20	1640	1×10^{7}
Manganese	55	25	25	1840	1×10^{6}*
Iron	56	26	24	1700	2×10^{8}
			16	1050	5×10^{7}*
Nickel	58	28	26	1810	1×10^{6}
Krypton	84	36	33	1510	1×10^{7}*
Niobium	93	41	35	1420	1×10^{8}
			23	770	8×10^{7}
Xenon	129	54	45	1280	5×10^{5}
	132	54	45	1240	1×10^{5}
	136	54	45	1180	3×10^{6}
Lanthanum	139	57	52	1410	1×10^{5}
			48	1260	4×10^{7}
			32	690	8×10^{7}
			29	587	6×10^{7}
Holmium	165	67	54	1170	2×10^{5}
Gold	197	97	61	1080	1×10^{5}
			37	490	1×10^{7}
			35	450	5×10^{6}
			11	50	1×10^{5}
Uranium	238	92	68	960	1×10^{6}
			40	410	1×10^{7}

* Low intensities are at experimenters' requests; no maximization has been done.

** (Ref. 1)

2.2 Beam Line Rigidity Limits

The Bevalac has a rigidity limit of 192 kG-m. Depending on the magnet, current and angular bend, each beam line has an upper limit in rigidity which it can transport. The rigidity is given by

$$R = \frac{R_o \gamma\beta}{(Q/A)} = P/q = \rho_{eff} B_{ev}$$

where R_o = 31.07155 kG-m $\equiv m_o c/e$

where $\gamma\beta = [\eta(2+\eta)]^{1/2}$

$$\eta = \frac{(T/A)}{W_o}$$

W_o = 931.5016 MeV/amu $\equiv m_o c^2$

q = charge state of the ion $\equiv$ Qe

m = atomic mass $\equiv Am_o$

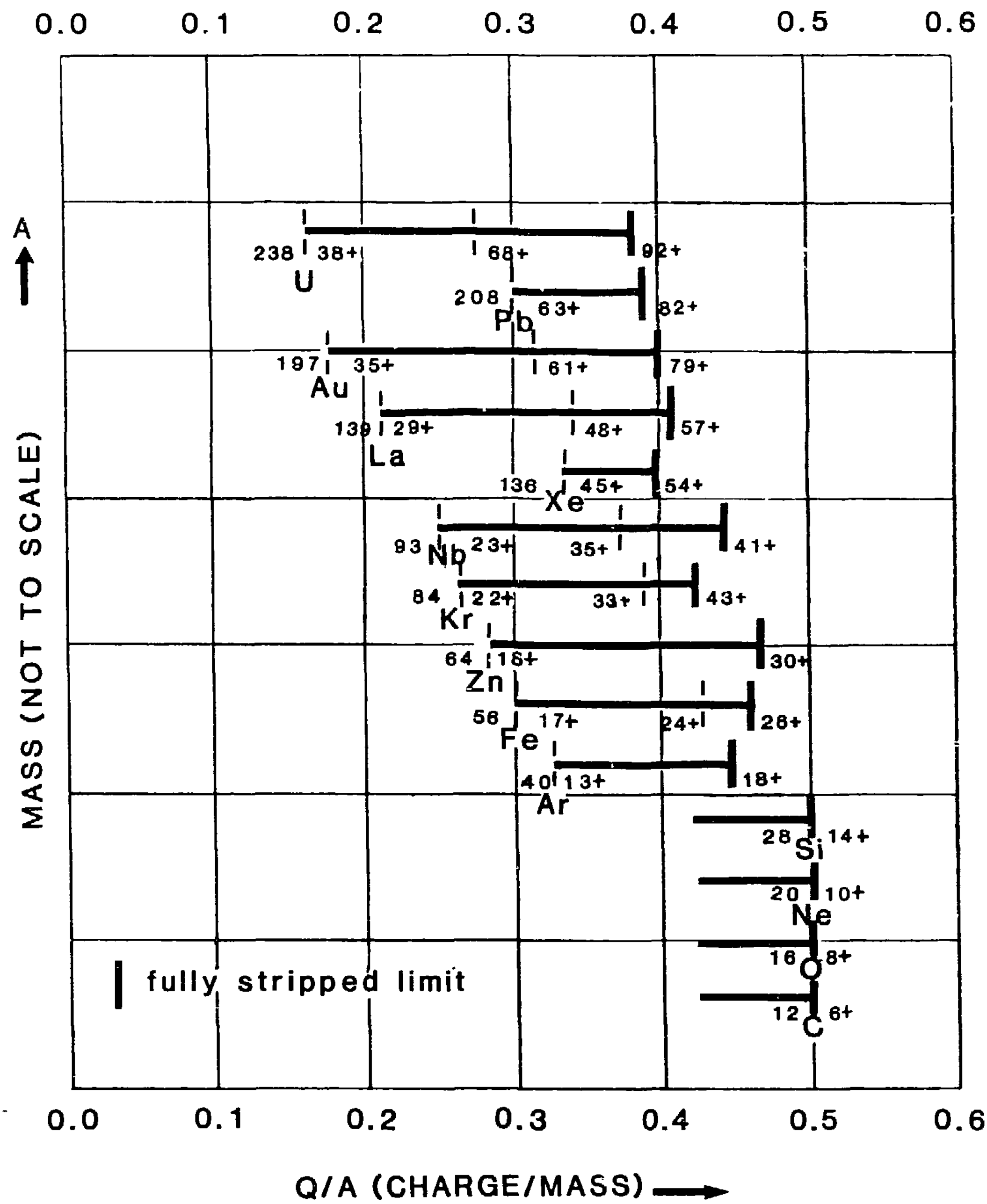
T = kinetic energy

p = momentum = mc $\gamma\beta$

B_{ev} = Bevatron field (1500-12575G)

ρ_{eff} = The effective extraction radius (15.21-15.31m)

The importance of the beam rigidity is that for a given beam optics the magnet field strengths (and currents) scale linearly with rigidity (where there is no magnet saturation). The following two pages allow one to determine the maximum energy for a given charge/mass ratio that a particular beam line can deliver. For an ion of mass A, Fig. 1A shows the charge/mass (Q/A) ratio for the various charge states. Then the maximum kinetic energy/amu that can be transported in a particular beam line is given in Fig. 1B for that particular (Q/A). (e.g. ^{136}Xe in the +45 charge state must have an kinetic energy below 295 MeV/amu to be transported down Beam Line 44, which has a rigidity limit of 80 kG-m).



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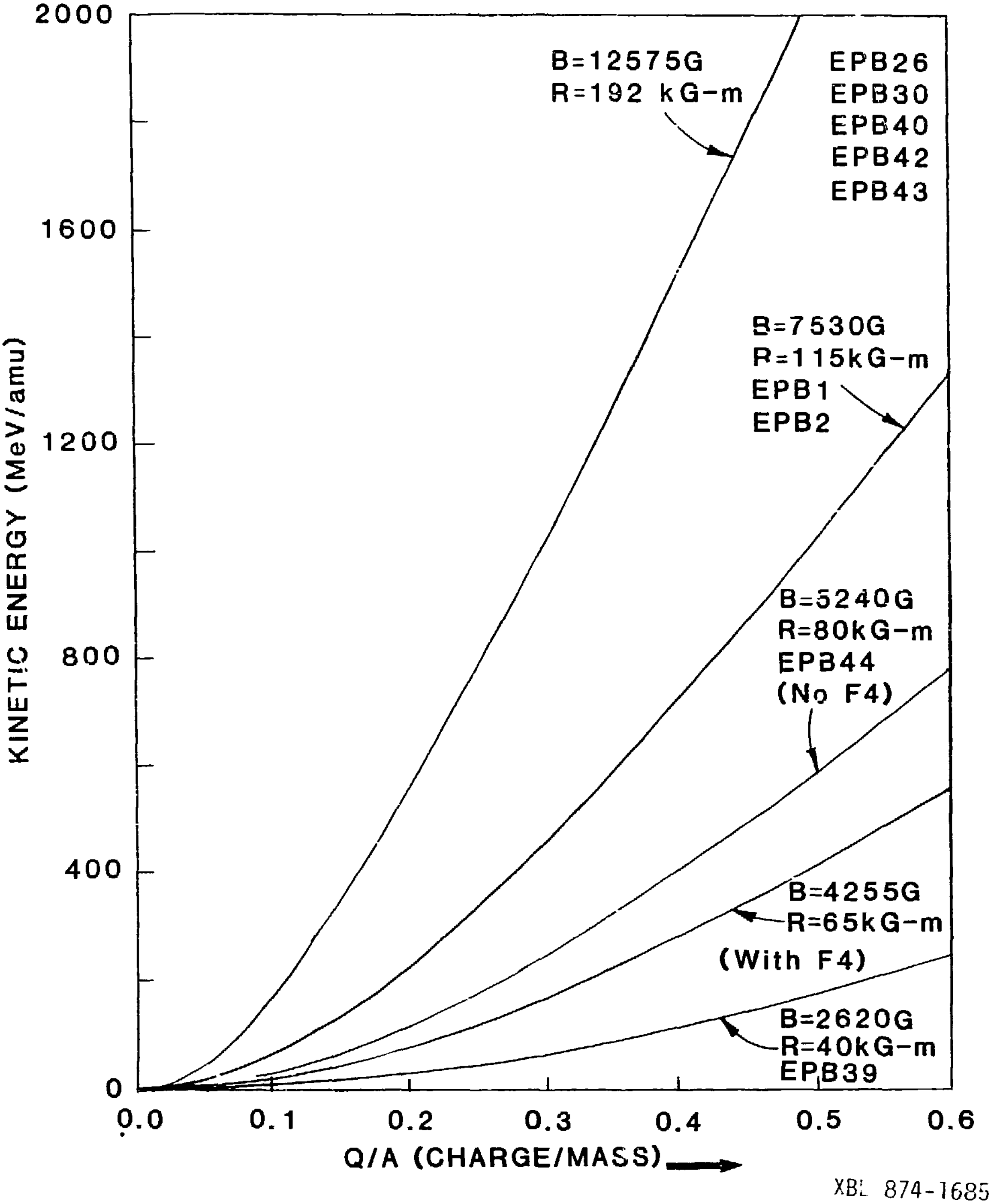
SOME HEAVY IONS ACCELERATED AT THE BEVALAC AND THEIR Q/A

Fig. 1A



KINETIC ENERGY VS Q/A FOR CONSTANT RIGIDITY

Fig.1B

Table 2.2.1

Rigidity for Ions with Charge/Mass of 0.5

T/A (MeV/amu)	γβ	R/(q/m) (kG-m)	R (kG-m)
10	0.146921	4.56506	9.13013
20	0.208332	6.47320	12.94640
30	0.255830	7.94905	15.89810
40	0.296187	9.20299	18.40598
50	0.332016	10.31625	20.63250
60	0.364655	11.33039	22.66078
70	0.394895	12.27000	24.54000
100	0.475638	14.77882	29.55764
150	0.589908	18.32935	36.65870
200	0.689575	21.42615	42.85230
250	0.780255	24.24372	48.48744
300	0.864780	26.87005	53.74010
400	1.021384	31.73597	63.47194
500	1.166900	36.25738	72.51476
600	1.305042	40.54967	81.09934
800	1.566921	48.68667	97.37334
1000	1.816466	56.44041	112.88082
1200	2.058168	63.95045	127.90090
1400	2.294506	71.29385	142.58770
1600	2.526986	78.51737	157.03474
1800	2.756584	85.65135	171.30270
2000	2.983966	92.71646	185.43292
2100	3.096979	96.22793	192.45586

Note that beam line 44 has a rigidity limit of 65 kG-m when the focal point (F4) before the quadrupole (B44Q2A) is used. A table of rigidities (2.2.1) is included for ions with Q/A = 0.5 at different energies.

2.3 Optics, beam envelope definitions

A charged particle moving down a beam line may be represented by a six dimensional vector (x, x', y, y', z, Δp/p). The components of the vector are the horizontal and vertical displacement (x and y) from the central trajectory (optic axis), the horizontal and vertical divergence (x' and y'), (see Fig. 2) the difference in length, z, between the longitudinal position of the particle and that of one at the central momentum, and the fractional momentum deviation Δp/p from the central momentum. The divergence x' is defined as the ratio of transverse to longitudinal velocities. That is $x' = dx/dz = v_x/v_z$, with a similar definition for vertical divergence. A plot of the horizontal divergence (x') vs the horizontal size (x) of a group of particles will approximate an ellipse as shown in Figure 2. (This is a projection of the six dimensional ellipsoid on the x'-x plane). The area of the ellipse is given by $E_x = \pi x_0 x_0'$ and is called the horizontal emittance: the vertical emittance is just $E_y = \pi y_0 y_0'$. A single particle can be traced through the transport system by matrix multiplication, and an extension of the matrix algebra provides a means for defining and tracking a beam of particles through a series of magnets and drift spaces. Computer programs such as TRANSPORT or LATTICE) represent the beam of particles as an ellipsoid in the six dimensional coordinate system. The input to such programs are the initial six coordinates of the ellipse (x_0, x_0', y_0, y_0',

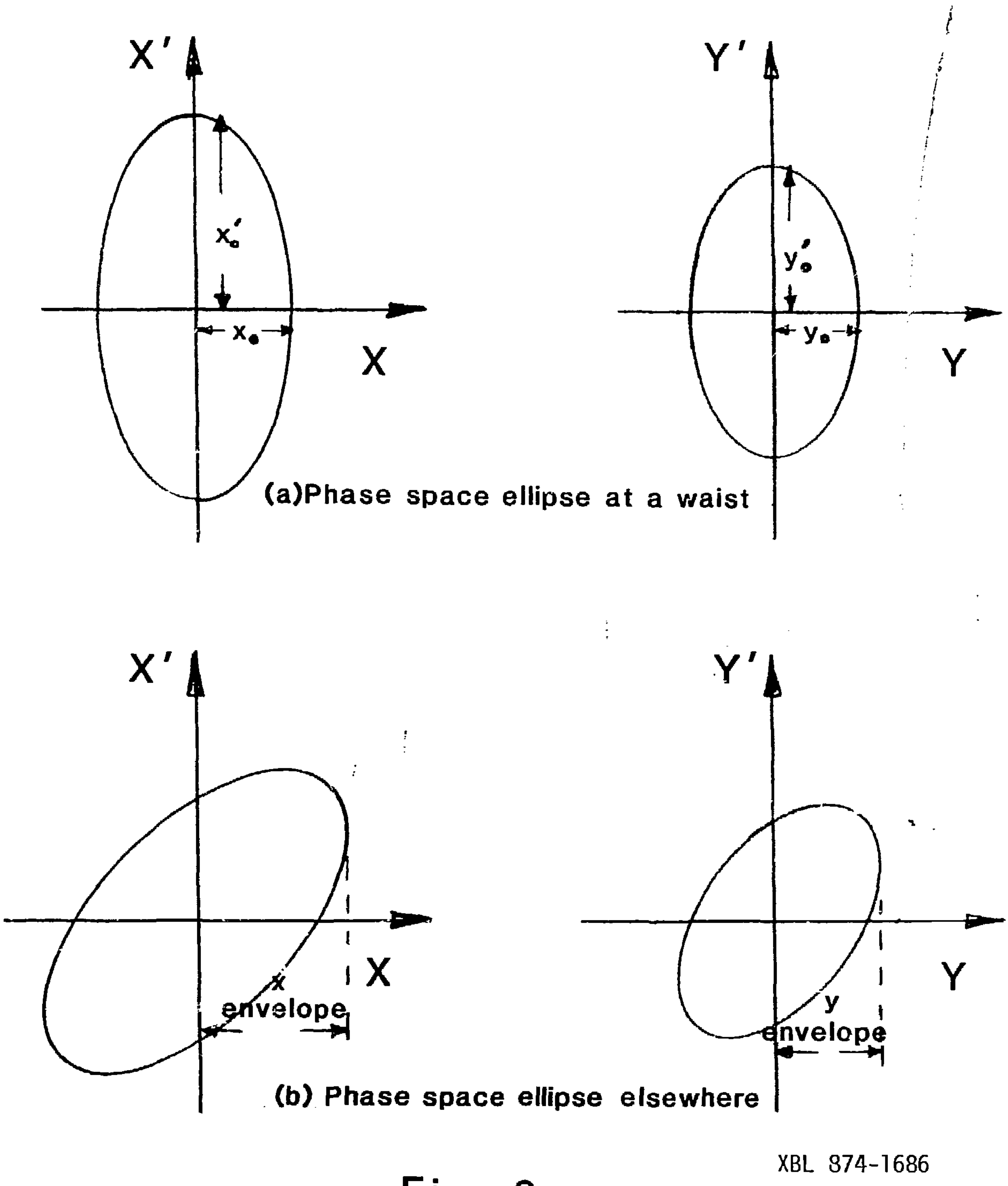


Fig. 2

The phase space ellipse (divergence horizontally or vertically vs beam width horizontally or vertically)

z_0, $\Delta p/p$) – see Fig. 2) when emerging from the accelerator, and the beam line magnet positions and field strengths. In Table 2.3.1 we list the maximum transportable angular divergencies (x_0', y_0') and momentum spread ($\Delta p/p$) specified at the initial F1 focal point, for the Bevalac beam lines. Typically, the output from such computer programs is a tracing down the beam line of the extreme trajectories (both horizontally and vertically) of a group of particles. The emittance we will use, will be one which contains 98% of the beam within the extreme trajectories, called the <u>beam envelopes</u>. On wire chamber pictures, where the beam profile is approximately Gaussian, the beam envelope's horizontal half-width is then x(envelope) $\simeq 2.36\ X_{rms}$ $\simeq$FWHM with the same relation for the vertical envelope. The horizontal and vertical beam envelopes for the maximum transportable emittance, and for a beam momentum spread $\Delta p/p$ = 1% are shown in Fig. 3 above and below the optic axis (center line), respectively. At the F1 focal point, the beam was taken to have an average size of $x_0 = y_0$ = 5mm. The divergences x_0' and y_0' were taken as the maximum acceptance values given in Table 2.3.1 for each beam line. If the actual initial divergence at F1 is smaller then this (see Sec. 2.5), the envelope will be the same at the subsequent focal points, but will be proportionally smaller near subsequent quadrupoles. The distance down the beam line or optic axis is given in meters while the half - widths of the horizontal and vertical envelopes are given in cm. Obstructions for a given beam line are generally not shown. The magnet names for a given beam line are listed at the top of each page as well as whether a given quadrupole is horizontally (H) or vertically (V) focussing. Note the following aspects of the envelope pictures:

Table 2.3.1

<u>Bevalac Beam Line Acceptances</u>

Beam Line	Angular divergence at F1		Momentum Spread at F1 $\pm\Delta p/p$
	Horizontal $\pm x'_o$	Vertical $\pm y'_o$	
26	7.5 mr	4.2 mr	0.85 %
30	7.5	5.0	0.73
39	6.1	7.5	0.60
40	7.5	4.7	1.5
42	3.7	6.4	6.2
43	3.7	4.1	6.2
44 (I)	7.5	5.0	0.73
44 (II)	7.5	20	0.73
Biomed I	3.7	6.4	4.2
Biomed II	3.7	6.4	0.85

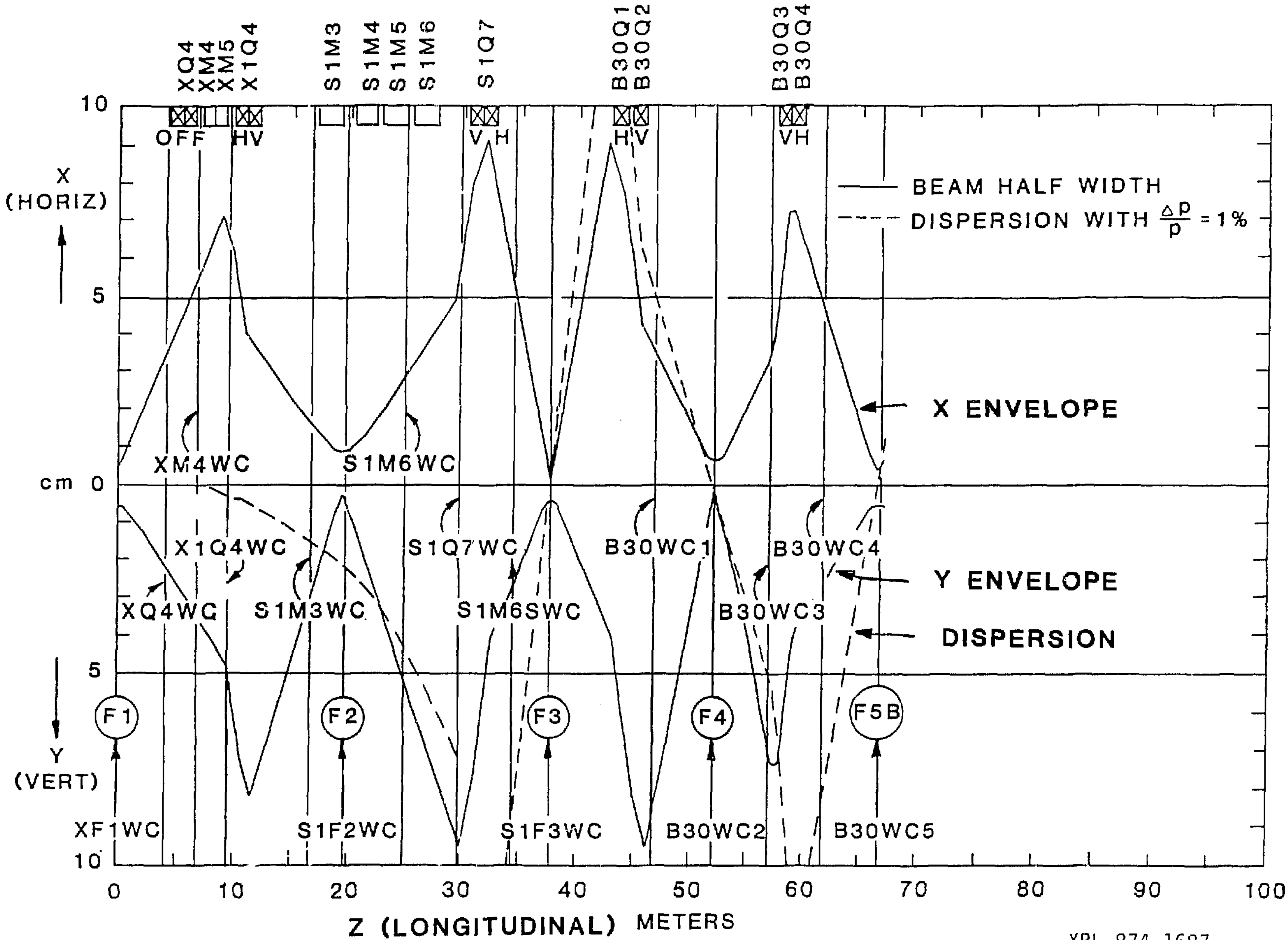


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FIG. 3

A. At Z = 0 on the optic axis the beam is assumed to have a certain horizontal and vertical size and divergence which will determine the initial emittance. The emittance of a beam of particles emerging from the Bevalac varies according to energy; low energy beams have emittances of about 30 π mm-mr while high energy beams have emittances of about 10 π mm-mr. (This is a consequence of adiabatic damping in the Bevalac). As the group of particles travels down the beam line the ellipse changes shape, but the area remains constant (if there are no obstructions). This is a statement of Liouville's theorem.

B. The dispersion d_x for a given beam line tune gives the horizontal displacement of a particle with a rigidity $(R + \Delta R)$ differing from the central rigidity R (Optics nomenclature often equates $\Delta R/R \simeq \Delta p/p$). The dispersion is proportional to $\Delta R/R$, that is $d_x = \delta_x \Delta R/R$ where δ_x is a function of the longitudinal position along the beam line. In the beam envelope pictures the dispersion is given by the dotted line for $\Delta R/R = 1\%$.

Dispersion is produced when a group of particles is bent by a dipole magnet. Particles with lower values of R are bent more than particles with higher values of R. Once off-axis, the dispersion vector will be focused or defocused by the subsequent quadrupole and dipole magnets. In Sec. 2.2 we see that a spread in beam rigidity can occur due to beam energy spread (ΔT), different isotopes (ΔA) or different charge states (ΔQ). The dispersion has two primary effects on beam optics:

(i) An energy spread in the beam produces an increase in beam size at a place where the dispersion vector is large. For example, at a focal point such as F2 in Fig. 3, and Guassian distributions in both coordinate and momentum space, the horizontal half-width becomes

$$x = \sqrt{x^2 \text{ (envelope)} + d_x^2} ,$$

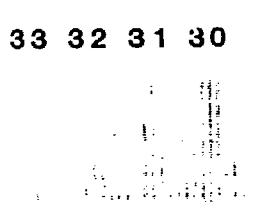
where x(envelope) is the monoenergetic half-width of the beam of particles. The momentum spread of the beam at the exit of the Bevalac is typically $\Delta p/p \leq 0.1\%$.

Usually, beam line optics are designed to give zero dispersion at the target focal point. A beam line of this design is called <u>momentum recombining</u>. This is a desirable quality for experiments whose results may be biased by a dependency on target interaction point with momentum. Beams of this type also have a minimum variation in beam size with respect to beam energy changes. Those positions along the beam line where the dispersion is non-zero will show greater beam movement. For maximum beam stability at the target it is important to have beam optics such that

(a) The beam is centered going through all the beam line quadrupoles.

(b) The dispersion ≈ 0 at the target with minimal slope $\Delta d_x/\Delta z \approx 0$.

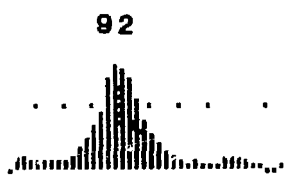
(ii) A second effect of dispersion is to separate beams of different charge or isotopic mass. As an example, 50 MeV/amu ^{139}La in the +30 charge state traveling through a poor vacuum (8×10^{-5} Torr) in the F1 area produced by electron loss the charge state distributions shown below at the S1M3 wire chamber and the F2 wire chamber. At the S1M3 wire chamber the dispersion is 14mm for each % change in rigidity. At the F2 wire chamber the dispersion is 21 mm/% and some of the charge states have been bent out of the detection area of the wire chamber.



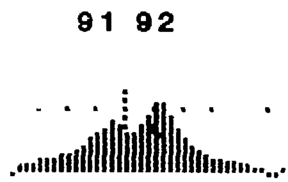
S1M3 Wire Chamber

S1F2 Wire Chamber

Another example is shown below. The wire chamber distribution on the left is that of a 450 MeV/amu U (+92) beam at the Beam 40 wire chamber 2 (wires have a 2 mm spacing). When the Beam 40 wire chamber 1 is inserted upstream of wire chamber 2 a new charge state, U (+91), appears on wire chamber 2. This is an example of electron capture.



B40 Wire Chamber 2



B40 Wire Chamber 2 with B40 Wire Chamber 1 Inserted

With the use of collimators we can select the desired charge state or isotopic mass to be transmitted. The Bevalac beam lines contain a number of collimators. A list is given in Sec. 2.7. Collimators placed near a focal point (waist) are effective in reducing the beam spot size at the subsequent focal points. As well, collimators located near quadrupoles do not change the spot size but reduce the beam divergence at the subsequent focal points.

2.4 Explanation of the magnet parameter lists, wire chamber pictures and magnet current lists.

A. Magnet Parameter Lists (See Sec. 3.1.2)

The magnet parameter lists give the optic elements for input into a beam transport computer program. The names of the magnets are given in column one. Starting at the first focal point of the Bevalac in the external particle beam region XF1, the effective magnet lengths and drift spaces are listed in column two. In columns three and four the quadrupole maximum gradients and pole tip radii are given respectively. The following five columns give information about the dipoles in a given beam line. First, the magnetic field required to bend a maximum rigidity (192 kG-m) particle is given followed by the dipole's bend radius, bend angle and finally edge angle. The edge angles are the angles that the pole tips make with respect to the incoming and outgoing beam. The sign convention can be obtained by examining the Bevalac map and the magnet list. Finally, the magnet type is given. The dipole dimensions are listed in the order of gap, pole tip width and pole tip length. Some of the magnet parameters may be found in the Bevatron/Bevalac User's Handbook.

B. Wire Chamber Pictures (See Sec. 3.1.4)

The name of each wire chamber along a given beam line is located on the right of the wire chamber pictures. After the name, the voltage applied to that chamber is listed. Higher voltages are required when the particle flux is low. (The 6mm wire chambers are more sensitive for detection of low particle fluxes). On the next line the auto-ranging information is given. A0 with a black background auto-ranges the amplitude of the wire chamber distributions the most while A7 changes the amplitude the least. Following the ranging information the wire spacing distance is given. The horizontal display of each wire chamber is shown on the left followed by the vertical display. Given next to each distribution are the mean and the standard deviation from that mean of the wire number distribution. In most cases beam center is physically located at wire #16. The four vertical dots indicate the central position. Looking downstream, if the horizontal and vertical wire chamber distributions are to the left of center then the beam is to the left and above the surveyed central or optic axis of the beam line. It is important to realize that the mean and standard deviation of the distribution of wire numbers is often distorted and in error due to noise on the chamber. The distributions can also be intensity dependent.

C. <u>Current Values of the Magnet</u> (See Sec. 3.1.4)

The current values associated with the wire chamber pictures are given on the following page. The name of each magnet for a given beam line is listed on the left side of the page. The current in each magnet is then given in the column with the heading AM.

Also listed on the current value page are the ion species, the main Bevalac field, the beam radius (FT RAD), the position of the extraction magnets (MICE) and information about the type of 'spill' used.

2.5 Emittance at F1

Using known distances between wire chambers and using the beam sizes at these wire chambers, one can estimate the emittance at F1, the first external focal point of the Bevalac. The distances between the initial wire chambers are

XF1 wire chamber to XQ4 wire chamber: 4.000 m

XF1 wire chamber to XM4 wire chamber: 6.493 m

XF1 wire chamber to X1Q4 wire chamber: 9.306 m

XF1 wire chamber to X2Q4 wire chamber: 14.439 m

Any two wire chambers may be used to determine the beam's size and divergence, or they may all be used for comparison. If r is the full-width at half-maximum beam size and L is the distance between the F1 wire chamber and some downstream wire chamber, the divergence r_o' is $r_o' \simeq r/L$. Shown in Fig. 4 are the vertical vs. horizontal full-width at half-maximum beam sizes in the F1 area. Shown in Fig. 5 are similarly the average vertical vs. horizontal divergences in the F1 area. These values are the average values from using all four wire chambers given above. We see (Fig. 6) that the (unnormalized) horizontal and vertical emittances are similar, with a value $\epsilon \simeq 20\ \pi$ mm-mr for the few samples of data taken. Due to beam cooling in the Bevalac accelerator, the emittance has a dependency on energy. Since the error in the horizontal and vertical emittances is large due to the crude determination of beam size and divergence from wire chamber pictures, we have averaged the horizontal and vertical emittances at a given energy. Shown in Fig. 6 is this average unnormalized emittance for some Bevalac fields. We estimate the error in the average emittance to be ± 25% for these samples.

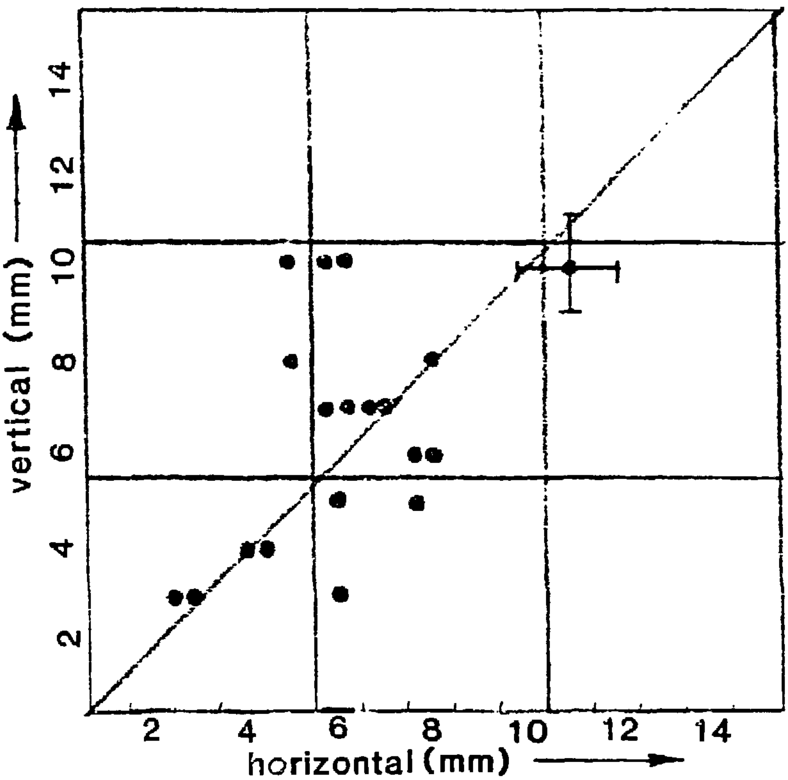


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FIG. 4

THE VERTICAL VS HORIZONTAL FULLWIDTH AT HALF MAXIMUM BEAM SIZE(mm) AT F1

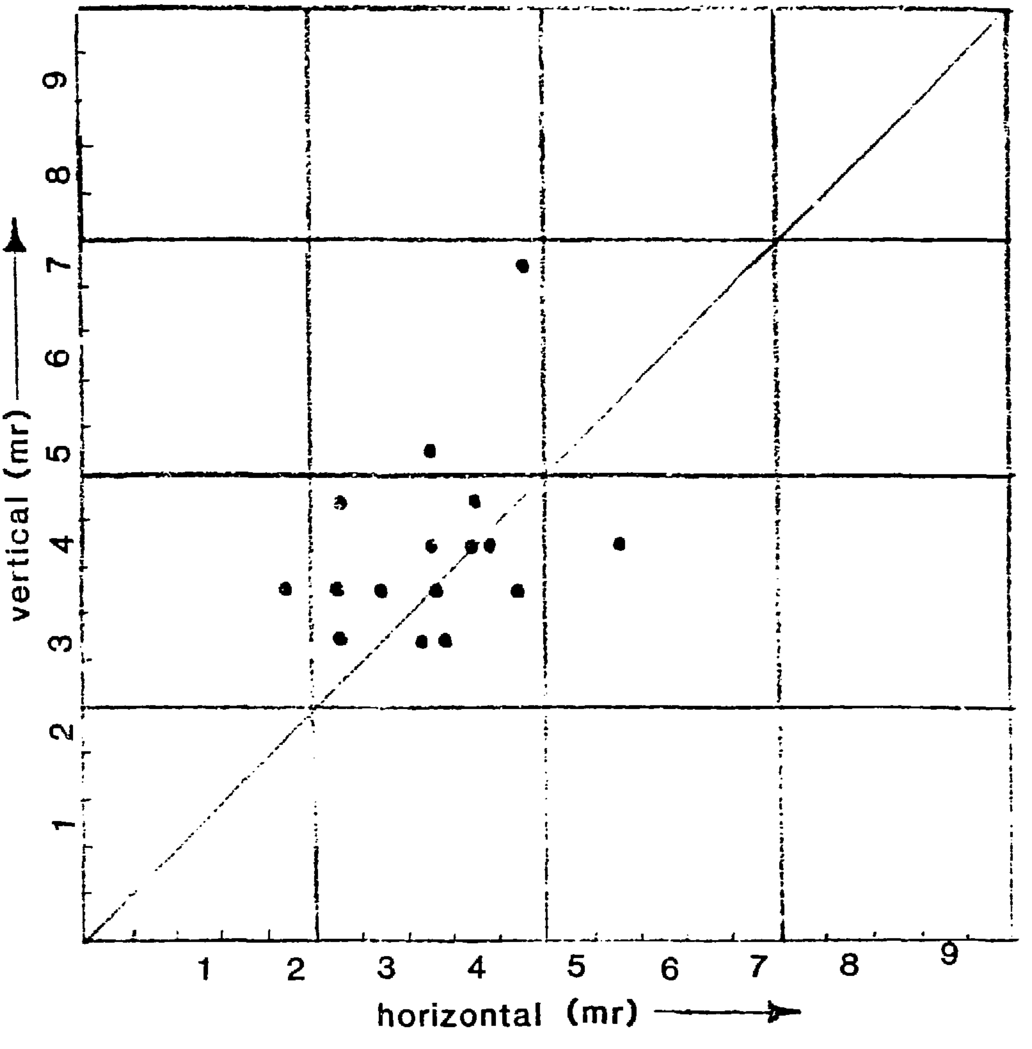

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FIG. 5

THE VERTICAL VS HORIZONTAL DIVERGENCE(mr) OF THE BEAM AT F1

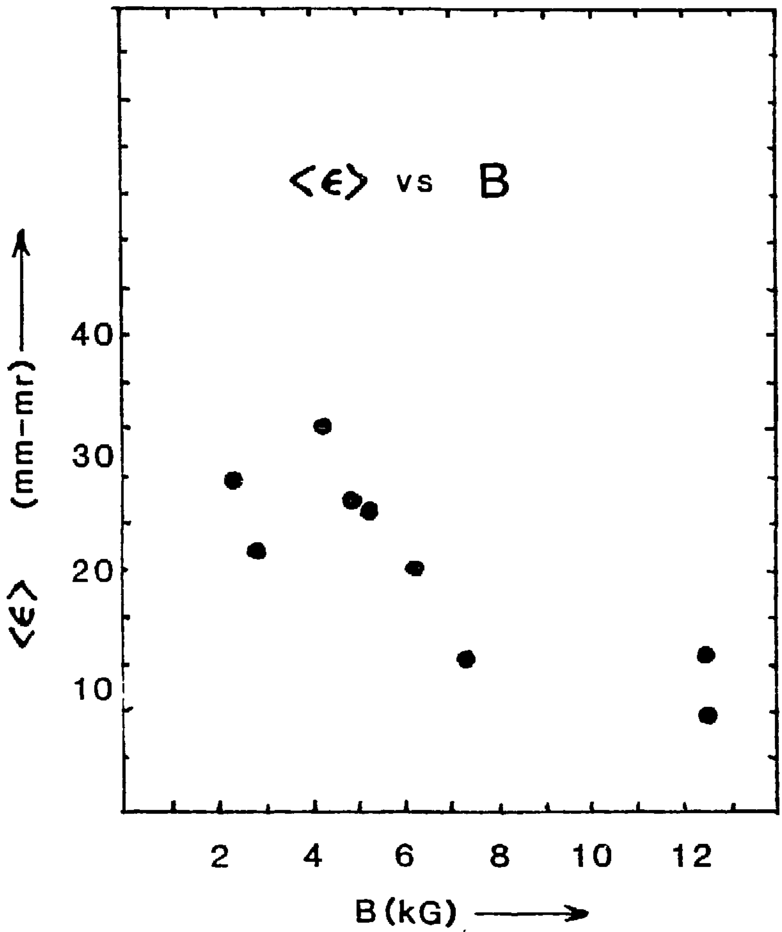

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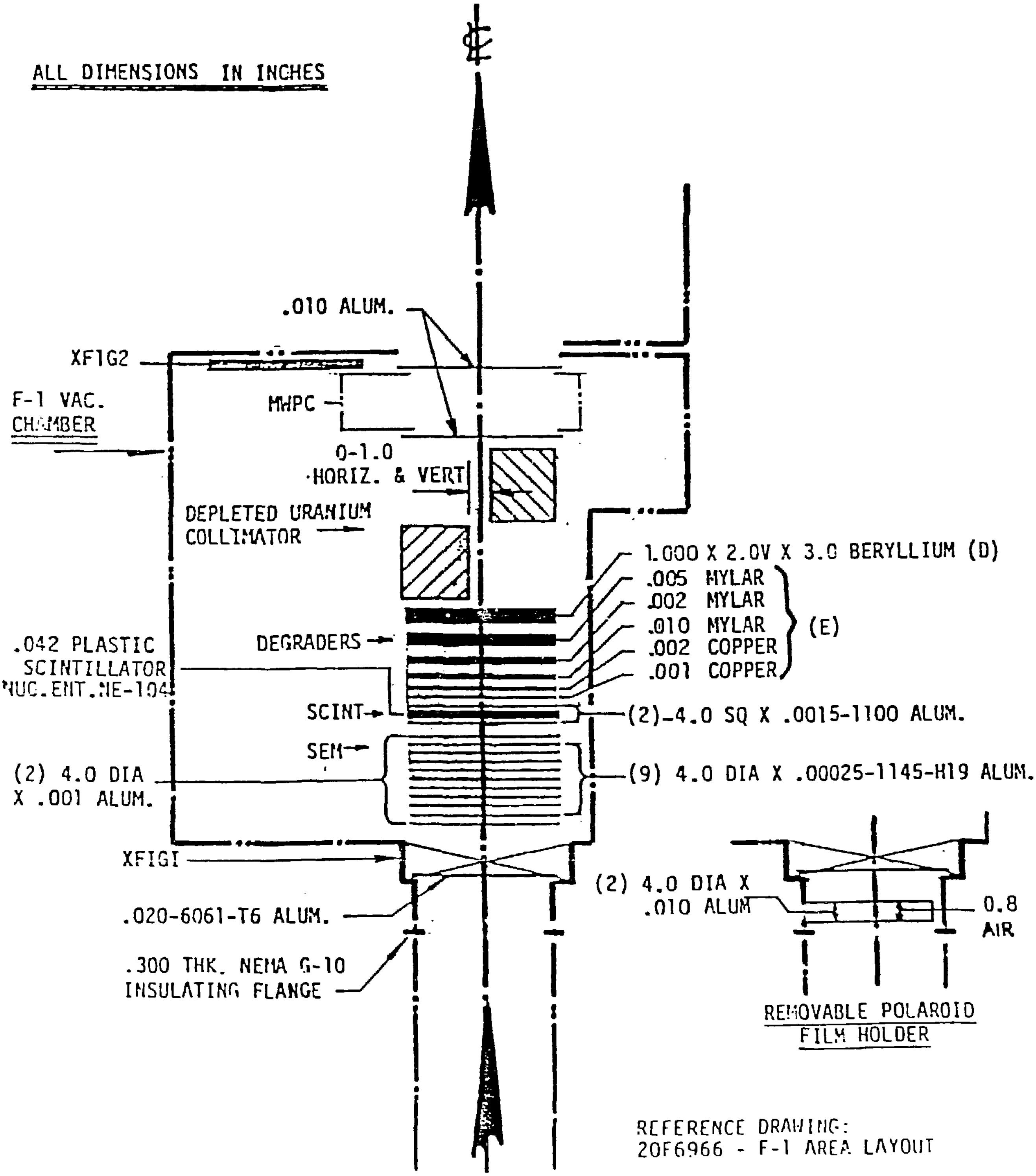
Fig. 6

The average of the horizontal and vertical emittances for various BEVALAC fields. (Error in $\langle \epsilon \rangle$ for a single data point $\pm 50\%$).

2.6 CONTENTS OF THE F1 BOX



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NOTE: THE FOILS AND THE DEGRADERS MAY BE CHANGED.

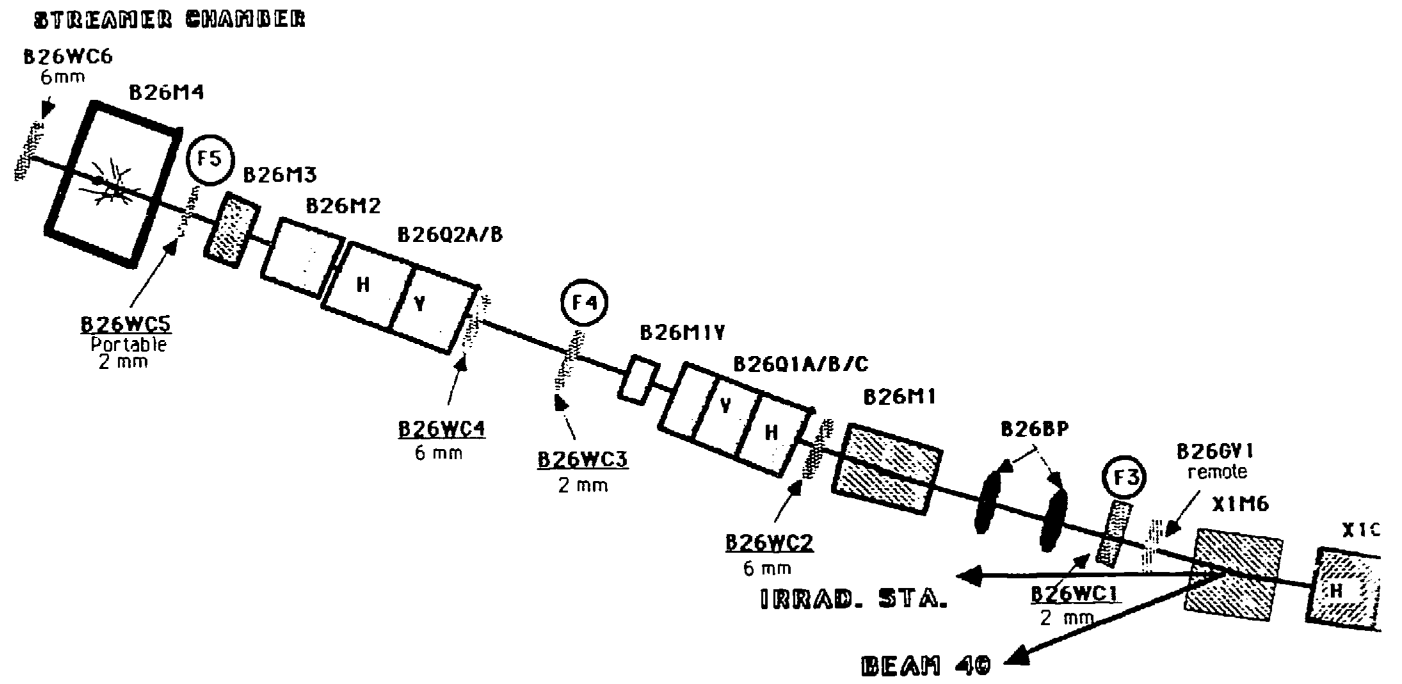
2.7 Collimators (Jaws) Index*

Name	Ass'y Print	Location	Position of Jaws	Size of Jaws (inches)	Material	Type
XF1JAWS	20E6116 (area)	F-1 Box	Ver./Hor.	4H x 4W x 4L	Depleted Uranium	Spot size
X1F2/S1F2JAWS	1844106	Dnstr. S1M3	Hor.	3-5/8x5-1/2x6-3/4	Lead	Spot size
X1JAWS	17J1536 17J3096 17J4733	Upstr. X1Q5WC	Ver./Hor.	3x8-5/8x24	Lead	Divergence
X2JAWS	20P4066 16P9376	Dnstr. X2M5S Dnstr. X2M5S	Ver. Hor. (Anderson)	 4-1/8x8-1/4x12	Lead Lead	Divergence
X2F2JAWS	16P9376	Upstr. X2F2WC	Ver. (Anderson)	4-1/8x8-1/4x12	Lead	Spot size
B40JAWS	N/A	Dnstr. B40WC1	Hor. (Manual)	2"x4"x8"	Lead	Spot size
B42JAWS	N/A Drive Unit 17G0016	Dnstr. B42WC1	Hor.	4"x8"x19"	Copper	Spot size Divergence
B39JAWS1	N/A From Brookhaven	Dnstr. B39WC3	Hor./Ver.	2-3/4x4x1.4CM 2-3/4x4x1/2 3-1/2x4x2	Carbon Lead Lead	Spot size
B39JAWS2	Same as #1	Dnstr. B39WC4	Hor./Ver.	3-1/2x4x2	Lead	Divergence
B0JAWS	N/A	Dnstr. B0S1	Hor.	4"x8"x10"	Lead	Spot size
S1F3JAWS	20E4066	Upstr. S1M7	Hor./Ver.	3-3/4x7-1/4x9-1/2	Lead	Spot size Divergence
B44SL1	20E4066	Dnstr. B44 Beam plug	Hor./Ver.	3-3/4x7-1/4x9-1/2	Lead	Spot size

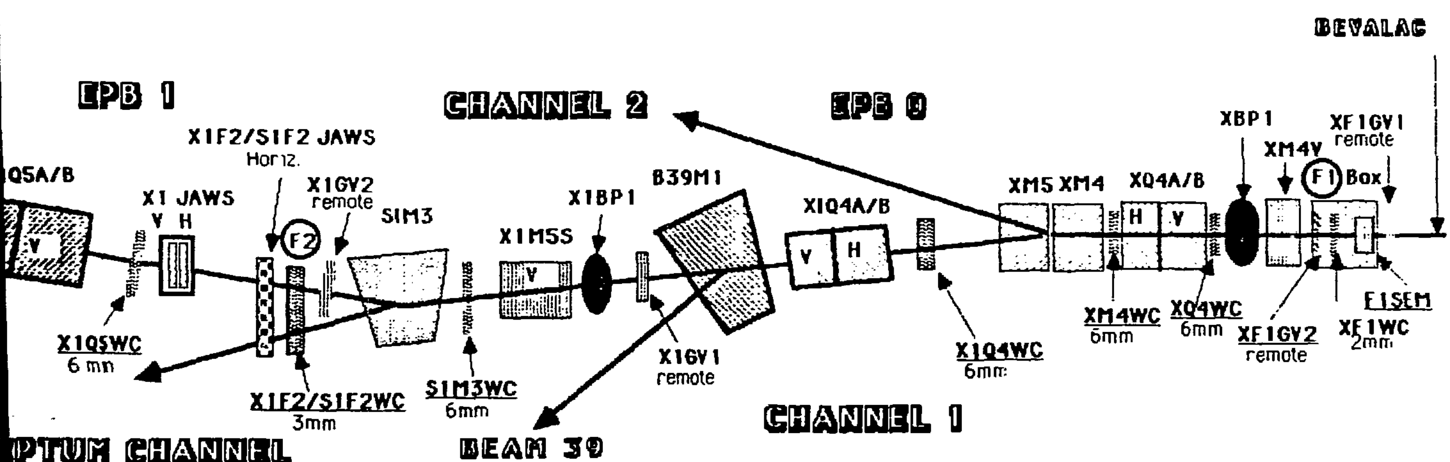
*(Ref. 2)

0981s
3/87 GK

3.1 Beam 26


STREAMER CHAMBER
B26WC6
6mm
B26M4
F5
B26M3
B26M2
B26Q2A/B
H
V
B26WC5
Portable
2 mm
B26WC4
6 mm
F4
B26WC3
2 mm
B26M1V
B26Q1A/B/C
V
H
B26WC2
6 mm
B26M1
B26BP
F3
B26GV1
remote
X1M6
B26WC1
2 mm
IRRAD. STA.
BEAM 40
H

BEAM 26



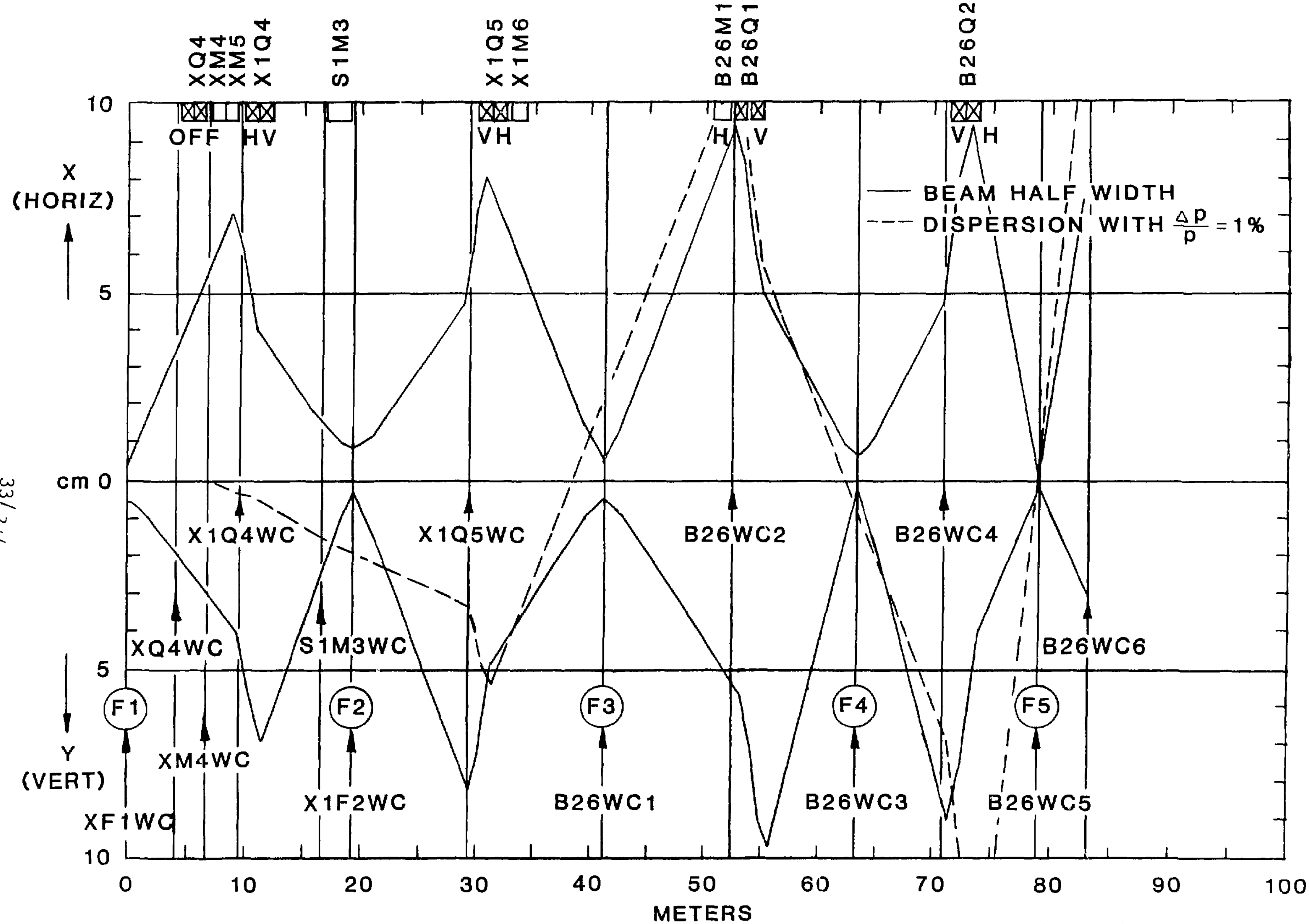
XBL 874-1706

3.1.2 Beam 26 Magnet Parameters

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
(F1)-XF1WC	-								
--- XQ4WC	4.000								
	0.221								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
--- XM4WC	0.220								
	0.242								
XM4	1.036			-16.88	11.37	5.222	0	5.222	6-1/8x18x36C
	0.173								
XM5	1.080			-13.50	14.22	4.351	-5.222	9.522	6-1/8x29x36H
--- X1Q4WC	0.282								
	0.235								
X1Q4A	0.884	+144	0.1046						8QN32
	0.284								
X1Q4B	0.884	-147	0.1046						8QB32
--- S1M3WC	4.862								
	0.340								
S1M3	2.250			4.51	42.58	3.028	0	3.028	4.38x15x84H
(F2)-X1F2WC	0.770								
--- X1Q5WC	9.480								
	0.240								
X1Q5A	0.884	-144	0.1046						8QN32
	0.306								
X1Q5B	0.884	+144	0.1046						8QN32
	0.361								

Beam 26 Magnet Parameters (cont.)

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
X1M6	1.036			20.05	9.577	6.2	0	6.2	6x16x36C
(F3)-B26WC1	8.600								
	9.500								
B26M1	1.542			16.74	11.47	7.7	3.85	3.85	6x18x60H
---B26WC2	0.435								
	0.308								
B26Q1A	0.884	+147	0.1046						8QB32
	0.177								
B26Q1B	0.490	-146	0.1046						8QB16
	0.120								
B26Q1C	0.490	-146	0.1046						8QB16
(F4)-B26WC3	8.214								
---B26WC4	7.055								
	0.484								
B26Q2A	1.308	-128	0.1048						8/12QB48
	0.181								
B26Q2B	1.308	+128	0.1048						8/12QB48
(F5)-B26WC5	5.140								
---B26WC6	4.060								

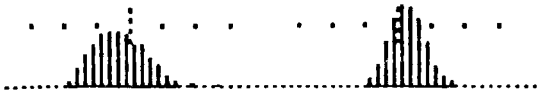


XBL 874-1692

SEC 3.1.3 BEAM 26

33/34

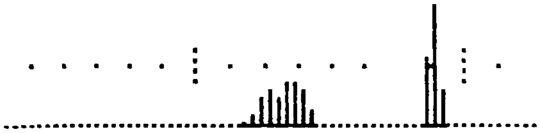
15.2
5.0



17.6
3.5

XM2 499 Volts
Auto Range 3 B On
21:47:49 23 Oct 86 3 MM

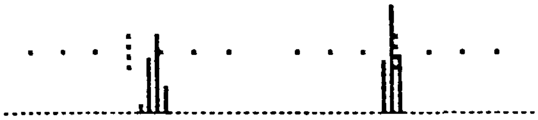
34.6
3.5



4.9
1.5

XM3 496 Volts
Manual Range 0 B On
21:49:31 23 Oct 86 3 MM

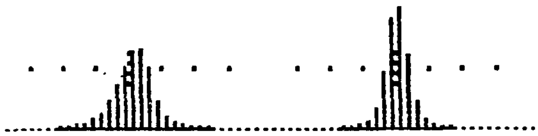
19.7
1.5



16.0
1.5

XF1 1000 Volts
Auto Range 1 B On
21:50:05 23 Oct 86 2 MM

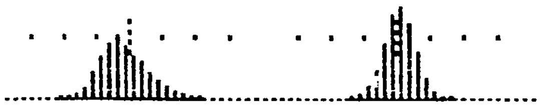
17.1
4.0



16.6
2.5

XM4 1050 Volts
Auto Range 5 B On
21:51:07 23 Oct 86 6 MM

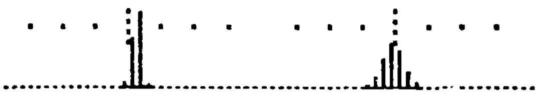
15.9
5.0



16.8
3.5

X1Q4 1000 Volts
Auto Range 5 B On
21:52:45 23 Oct 86 6 MM

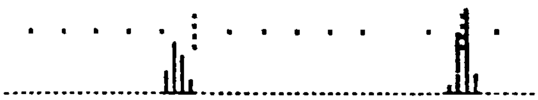
0.0
0.0



16.3
2.5

S1M3 747 Volts
Auto Range 3 B On
21:53:18 23 Oct 86 6 MM

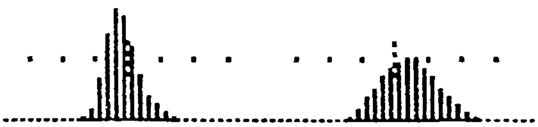
0.0
0.0



8.6
1.5

S1/X1F2 1001 Volts
Auto Range 2 B On
21:53:56 23 Oct 86 3 MM

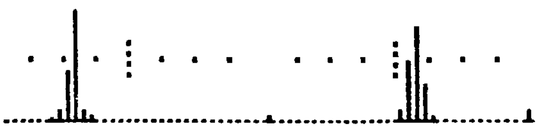
15.8
3.5



18.2
5.5

X1Q5 499 Volts
Auto Range 0 B On
21:54:24 23 Oct 86 6 MM

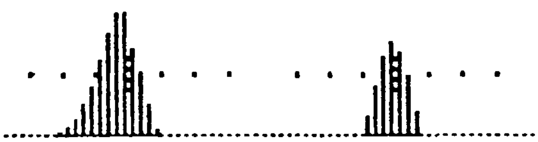
9.7
1.0



19.0
1.5

B26WC1 1498 Volts
Auto Range 2 B On
21:55:37 23 Oct 86 2 MM

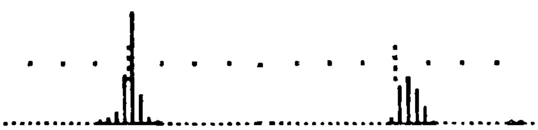
14.9
4.0



16.1
2.5

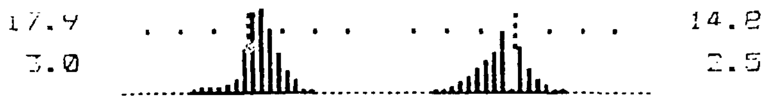
B26WC2 1502 Volts
Auto Range 3 B On
21:56:39 23 Oct 86 6 MM

20.2
3.5



16.3
2.5

B26WC3 1999 Volts
Manual Range 3 B On
21:59:24 23 Oct 86 6 MM



B26WC4 1250 Volts
Auto Range 3 B On
21:59:55 23 Oct 86 2 MM

B26WC5 2000 Volts
Manual Range 4 B On
22:01:07 23 Oct 86 2 MM

3.1.4 WIRE CHAMBER PICTURES AND MAGNET CURRENTS

NAME	DATE	TIME	ENTRY	BEAM LINE
NE7284 B26	23OCT86	22:16:13	8308	BEAM26

COMMENTS

NE7284 B26

BEAM TUNED TO B26WC5
UNABLE TO GET A NO QUAD STEETING TUNE
E 594.0 S 586.58
RADIUS 600.1
XS1 FEEDBACK SPILL
EXT PFW ACL 6390 EXT

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	79.33	400	1680
X	P2	P+	-3.20	400	1510
X	S2	S+	291.31	470	1300
X	S1	S+	51.28	440	1420
X	S2	P+	30.84	450	1100
X	M3	S+	-9.77	400	1400
X	S1	P+	36.71	400	1500
X	M2	S+	-32.08	400	1450

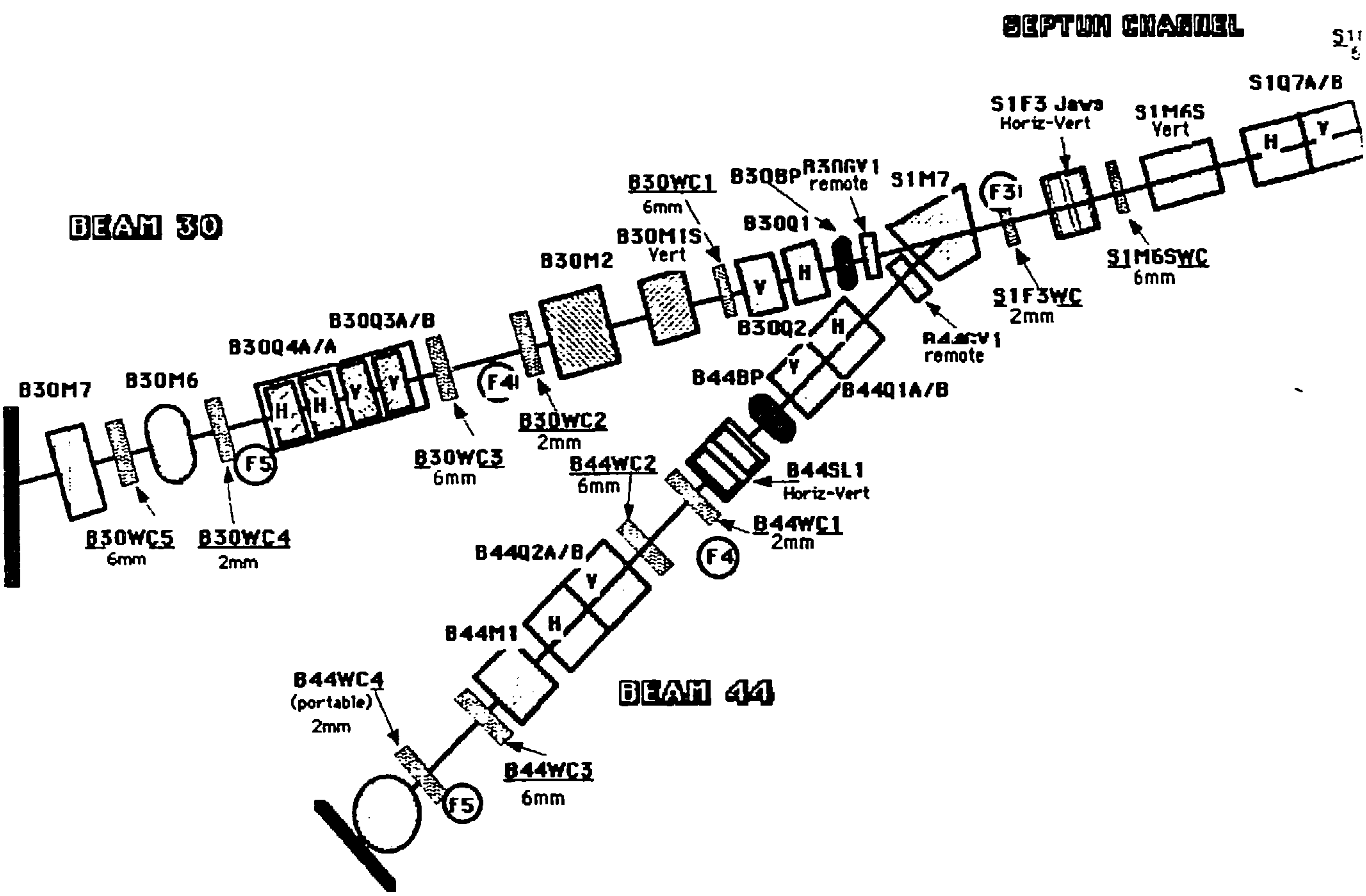
NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.29	5	0.00
X	S1	-1.68	1.32	5	0.00
X	S2	-0.06	2.08	5	0.00
X	M1	503.05	545.77	5	0.00
X	M2	1466.60	1504.49	2005	0.00
X	M3	1201.82	1218.76	5	0.00
X	Q3A	766.76	760.38	5	0.00
X	Q3B	750.92	817.05	5	0.00
X	M3V	10.00	9.40	2001	10.00
X	M4V	0.00	1.47	1	0.00
X	M4	617.84	617.59	2001	617.84
X	M5	301.42	304.45	2001	301.42
X1	Q4A	1135.91	1135.04	2005	0.00
X1	Q4B	1150.88	1201.56	2005	0.00
X1	M5S	54.53	54.11	2001	54.53
S1	M3	183.31	183.89	2003	183.31
X1	Q5A	1040.04	1035.61	2001	1040.04
X1	Q5B	1020.21	1018.61	2001	1020.21
X1	M6	764.29	756.08	2001	764.29
X	Q4A	0.00	0.00	5	0.00
X	Q4B	0.00	0.00	5	0.00
B26	M1	684.66	724.96	1	684.66
B26	Q1A	1119.87	1129.95	1	1119.87
B26	Q1B	1044.94	1056.67	1	1044.94
B26	Q2A	595.48	592.45	1	595.48
B26	Q2B	607.90	619.32	1	607.90
B40	M2+3	800.68	4.89	1	800.68

3.1.5 Beam 26 Focal Points

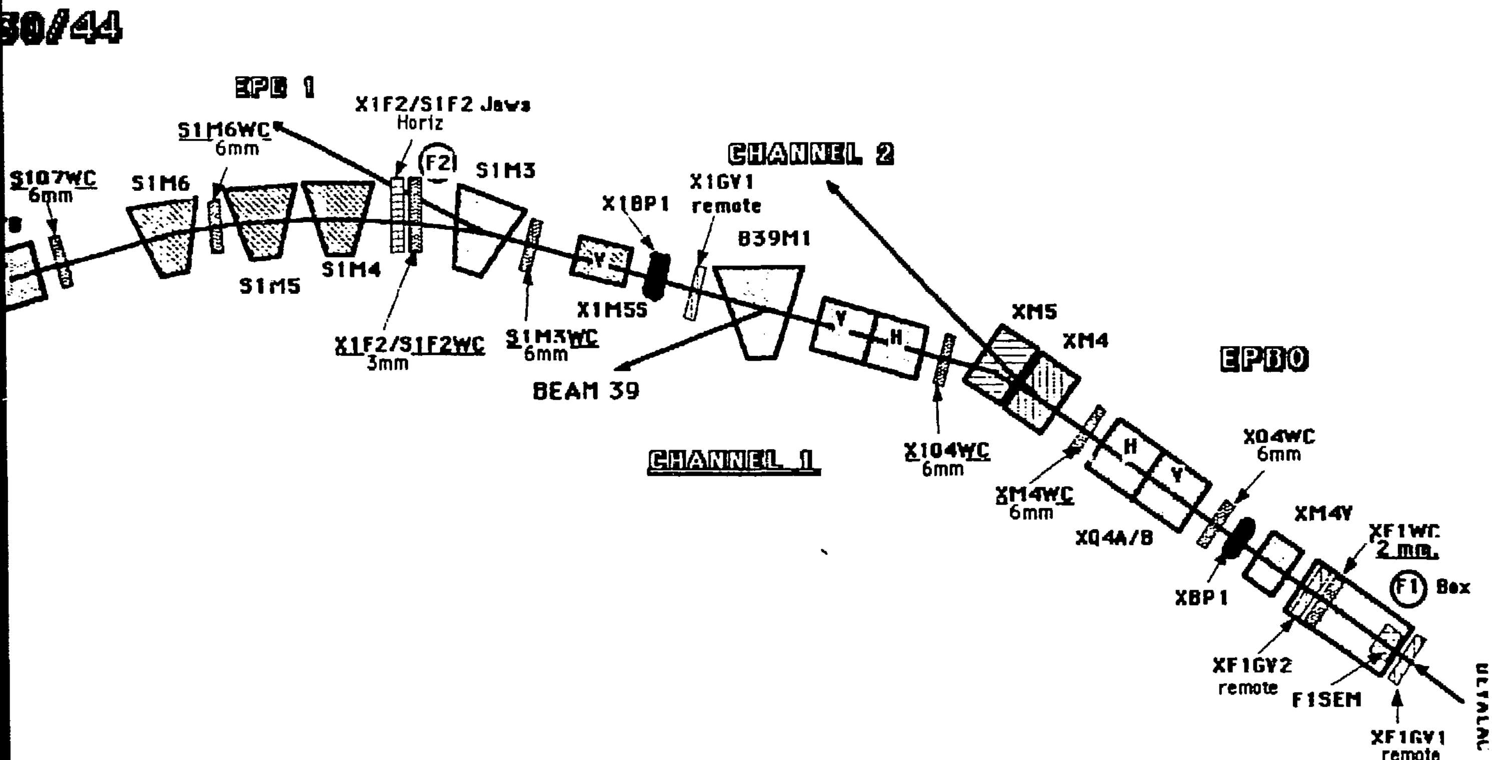
Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	X1F2WC	1.63	0.50	-19.4
F3	B26WC1	1.03	0.87	20.6
F4	B26WC3	1.25	0.35	-8.0
F5	B26WC5	0.42	0.56	2.3

3.2 Beam 30

BEAM 3(



SEPTUM CHANNEL
S1Q7A/B
S1F3 Jaws
Horiz-Vert
S1M6S
Vert
S1M7
F3
S1F3WC
2mm
S1M6SWC
6mm
BEAM 30
B30WC1
6mm
B30BP
remote
B30M1S
Vert
B30Q1
B30M2
B30Q2
B30Q3A/B
B30Q4A/A
B30M7
B30M6
F4
F5
B30WC2
2mm
B30WC3
6mm
B30WC4
2mm
B30WC5
6mm
B44BP
B44Q1A/B
B44SL1
Horiz-Vert
B44WC1
2mm
B44WC2
6mm
B44Q2A/B
B44M1
BEAM 44
B44WC3
6mm
B44WC4
(portable)
2mm



30/44
EPB 1
X1F2/S1F2 Jaws
Horiz
S1M6WC
6mm
F2
S1M3
CHANNEL 2
S1Q7WC
6mm
S1M6
X1GV1
remote
X1BP1
B39M1
S1M5
S1M4
X1M5S
XM5
XM4
X1F2/S1F2WC
3mm
S1M3WC
6mm
BEAM 39
EPBO
CHANNEL 1
X1Q4WC
6mm
XQ4WC
6mm
XM4WC
6mm
XM4V
XQ4A/B
XF1WC
2 mm.
XBP1
F1 Box
XF1GV2
remote
F1SEM
XF1GV1
remote

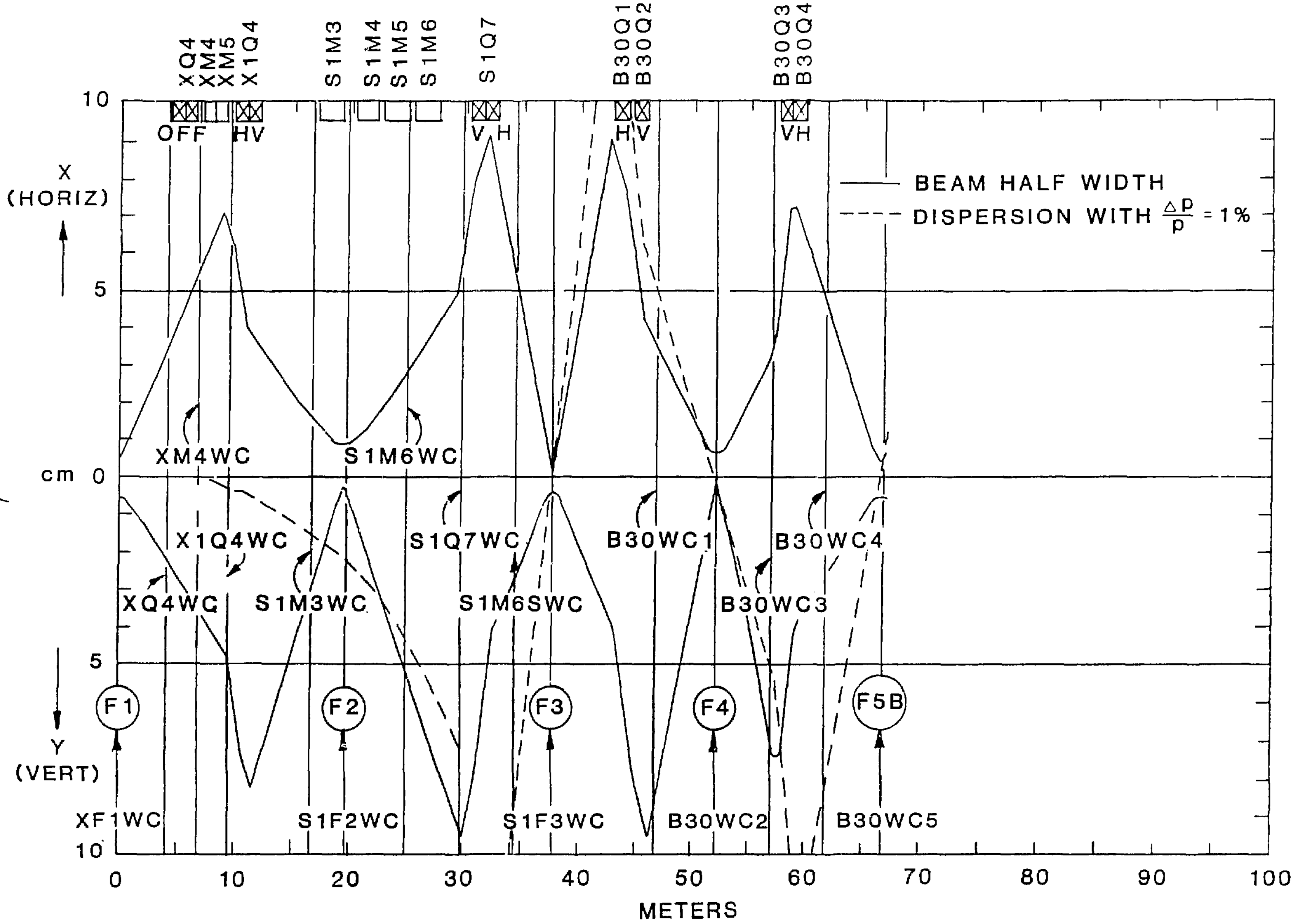
XBL 874-1704

3.2.2 Beam 30 Magnet Parameters

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
(F1)-XF1WC	-								
---XQ4WC	4.000								
	0.221								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
---XM4WC	0.220								
	0.242								
XM4	1.036			-16.88	11.37	5.222	0	5.222	6-1/8x18x36C
	0.173								
XM5	1.080			-13.50	14.22	4.351	-5.222	9.522	6-1/8x29x36H
---X1Q4WC	0.282								
	0.235								
X1Q4A	0.884	+144	0.1046						8QN32
	0.284								
X1Q4B	0.884	-147	0.1046						8QB32
---S1M3WC	4.862								
	0.340								
S1M3	2.250			-4.42	43.44	2.968	0	2.968	4.38x15x84H
(F2)-S1F2WC	0.770								
	0.645								
S1M4	1.405			-14.31	13.41	6.0	0	6.0	2¼x7½x48H
	0.370								
S1M5	2.250			-16.38	11.72	11.0	5.5	5.5	4x38x15x84H
---S1M6WC	0.247								
	0.247								

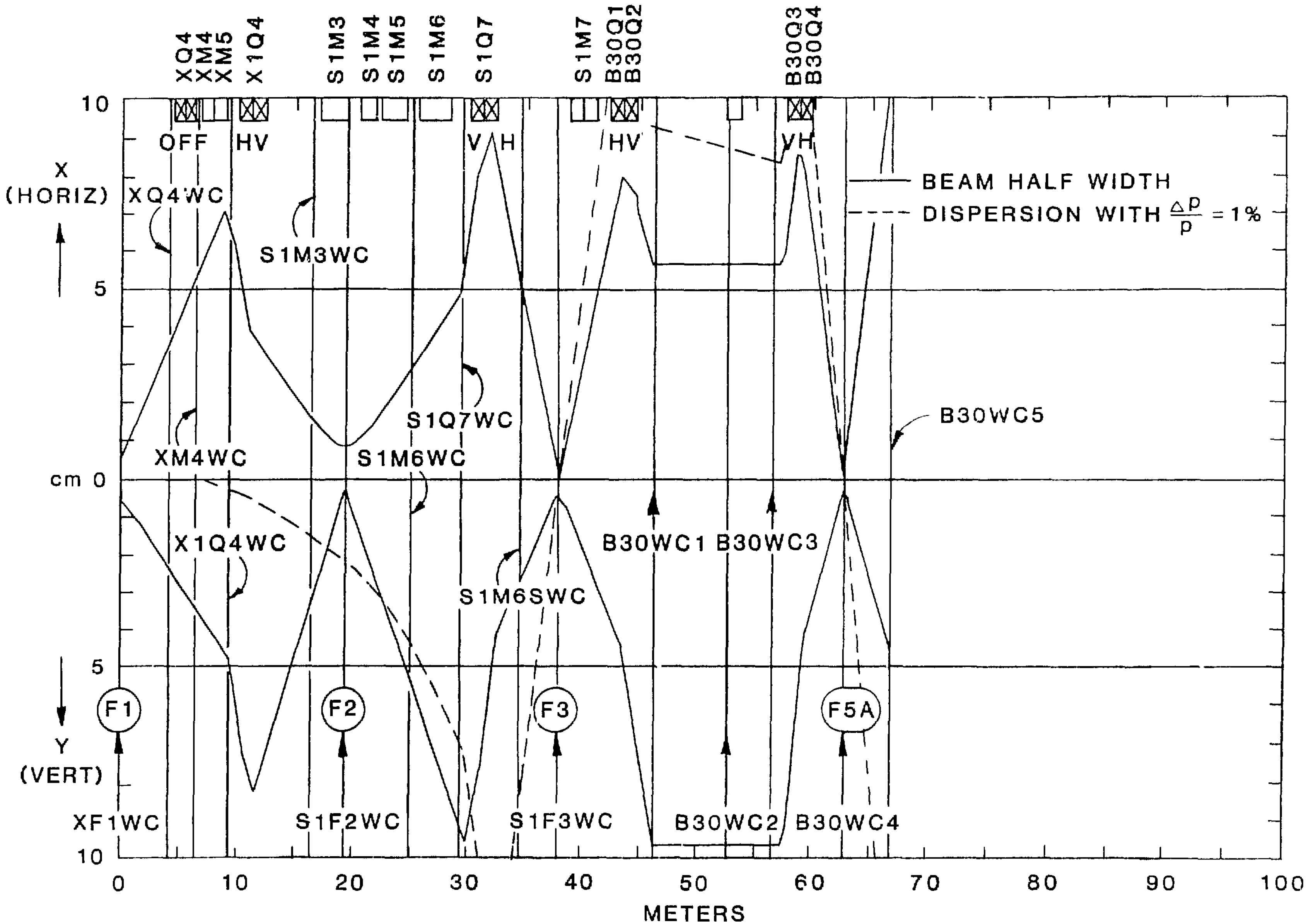
Beam 30 Magnet Parameters (cont.)

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
S1M6	2.250			-6.18	31.07	4.15	4.15	0	4.38x15x84H
---S1Q7WC	2.350								
	0.336								
S1Q7A	1.308	-138	0.1046						8QB48
	0.216								
S1Q7B	1.308	+138	0.1046						8QB48
---S1M6SWC	1.608								
(F3)-S1F3WC	3.700								
	5.280								
B30Q1	1.308	+128	0.1048						8/12QB48
	0.218								
B30Q2	1.308	-128	0.1048						8/12QB48
---B30WC1	0.594								
(F4)-B30WC2	5.760								
---B30WC3	4.660								
	0.185								
B30Q3A	0.490	-146	0.1046						8QB16
	0.120								
B30Q3B	0.490	-146	0.1046						8QB16
	0.145								
B30Q4A	0.490	+146	0.1046						8QB16
	0.120								
B30Q4B	0.490	+146	0.1046						8QB16
(F5A)-B30WC4	3.315								
(F5B)-B30WC5	3.830								



XBL 874-1693

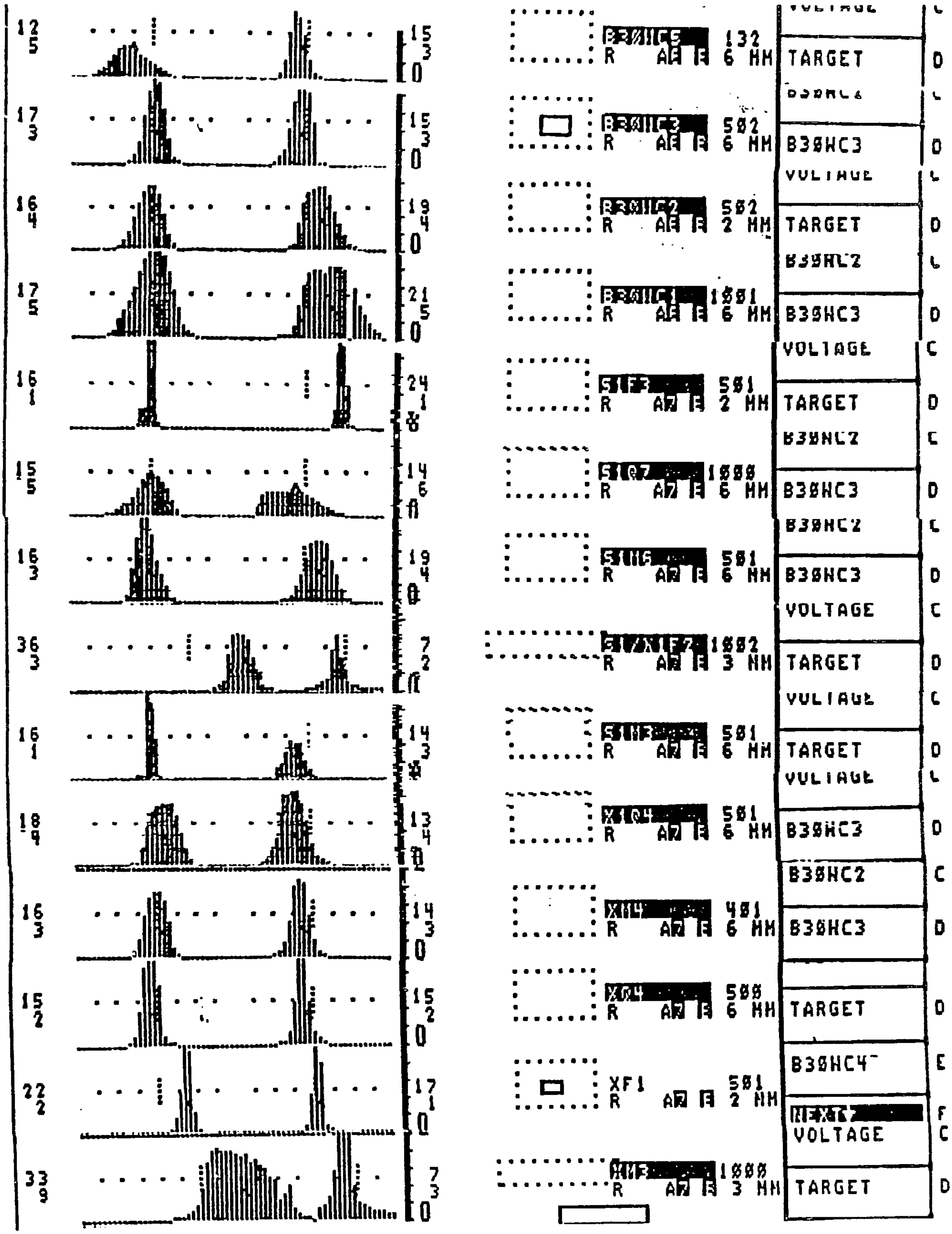
SEC 3.2.3 BEAM 30 (I)



XBL 874-1694

SEC 3.2.3 BEAM 30 (II)

OPTICS(I)



3.2.4 WIRE CHAMBER PICTURES AND MAGNET CURRENTS

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT 5B30	29MAR86	15:42:43	0	BEAM30

COMMENTS

NB37 12.5B30 1.54GEV/N NB37 STRIP 41 TO B30.
E 594.0 S 586.6
RAD. 600 FFT 2.311MHZ.
XS1 FDBK. SPILL.
EXT PFWS: "12575/EXT".
WIRE 23 AT F1. ALL STD F1 MAT. IN.

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	187.66	400	1200
X	P2	P+	-0.71	410	1210
X	S2	S+	7.71	400	1030
X	M2	S	-30.66	400	1190
X	S1	S+	106.54	400	1450
X	M3	S+	-15.21	400	1220
X	S1	P+	99.01	460	1690

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.88	5	0.00
X	P2	0.00	0.00	5	0.00
X	S1	-3.00	0.44	5	0.00
X	S2	-0.18	3.42	5	0.00
X	M1	896.19	969.72	5	0.00
X	M2	2328.92	2334.73	5	0.00
X	M3	1382.42	1907.28	5	0.00
X	Q3A	1350.15	1359.55	5	0.00
X	Q3B	1295.37	1422.33	5	0.00
X	M3V	71.20	70.59	2001	71.20
X	M4V	0.00	0.73	1	0.00
X	M4	1076.07	1075.82	2001	1076.07
X	M5	431.66	436.15	2001	431.66
X1	Q4A	1801.24	1833.21	7	0.00
X1	Q4B	1864.71	1888.47	5	0.00
X1	M5S	0.00	3.52	2001	0.00
X	Q4A	0.00	0.00	5	0.00
X	Q4B	0.00	0.00	5	0.00
S1	M3	272.66	276.22	2001	272.66
S1	M4	2719.27	2711.92	5	1199.99
S1	M5	967.35	967.93	2005	564.66
S1	M6	425.97	429.34	2001	425.97
S1	Q7A	1307.98	1295.66	5	0.00
S1	Q7B	1418.60	1453.43	5	0.00
S1	M6S	35.00	33.38	1	35.00
S1	M7	43.56	48.17	1	43.56
S1	Q1	1100.00	1100.00		
S1	Q2	1070.00	1070.00		
S1	Q3A/B	2550.00	2550.00		
S1	Q4A/B	2360.00	2360.00		

DATA FOR ENERGY CALCULATION

INJECTION:HILAC LOCAL

PARTICLE: Nb 2S FREQ : 372.2

MASS NUM: 93 2S FIELD: 629

CHARGE : 37+/41 K.ENERGY: 1537 MEV

INFLECTOR H.V:

EXTRACTION: PFW: (ON:) OFF:

FIELD: 12.575 kG P1 CUR:

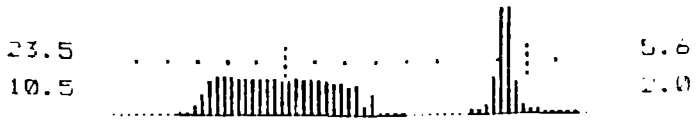
FREQ: 2.311 MHz P2 CUR:

BEAM RAD: 600

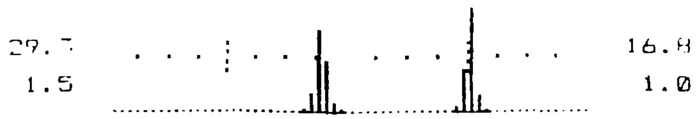
RADIUS	CURRENT	TAIL WAG	
M1: 594	:	RISE:	GAUSS
M2: 586.6	:	TIME:	mSECS
M3: ------	:	S1 (ON:)	OFF:
		S2 ON:	OFF:

STD MATERIAL AT F1: (IN:) OUT:

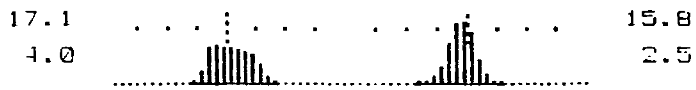
OPTICS (I)



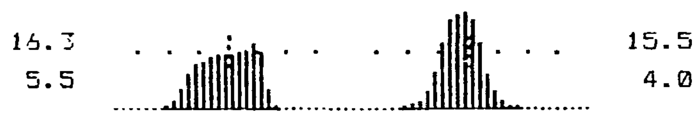
XM3 500 Volts
Manual Range 5 B On
23:10:39 13 Jan 87 3 MM



XF1 500 Volts
Auto Range 7 B On
23:11:02 13 Jan 87 2 MM

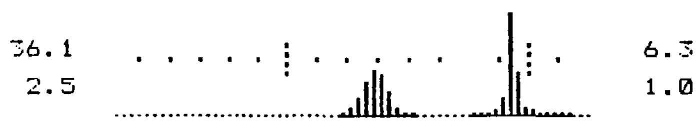


XM4 500 Volts
Auto Range 7 B On
23:11:42 13 Jan 87 6 MM

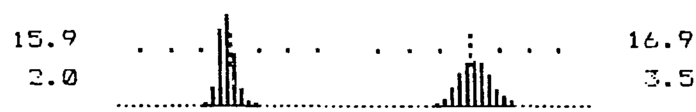


X1Q4 500 Volts
Auto Range 6 B On
23:12:18 13 Jan 87 6 MM

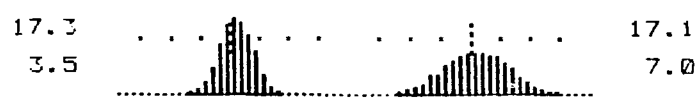
S1M3 750 Volts
Auto Range 7 B On
23:12:51 13 Jan 87 6 MM



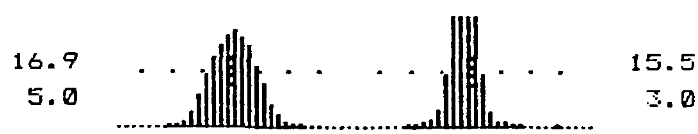
S1/X1F2 300 Volts
Auto Range 6 B On
23:13:30 13 Jan 87 3 MM



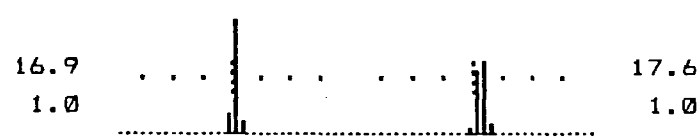
S1M6 500 Volts
Auto Range 7 B On
23:14:21 13 Jan 87 6 MM



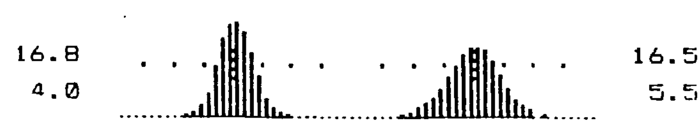
S1Q7 1000 Volts
Auto Range 7 B On
23:14:52 13 Jan 87 6 MM



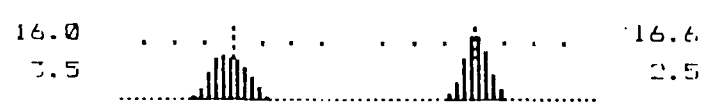
S1M6S 1000 Volts
Auto Range 7 B On
23:15:43 13 Jan 87 6 MM



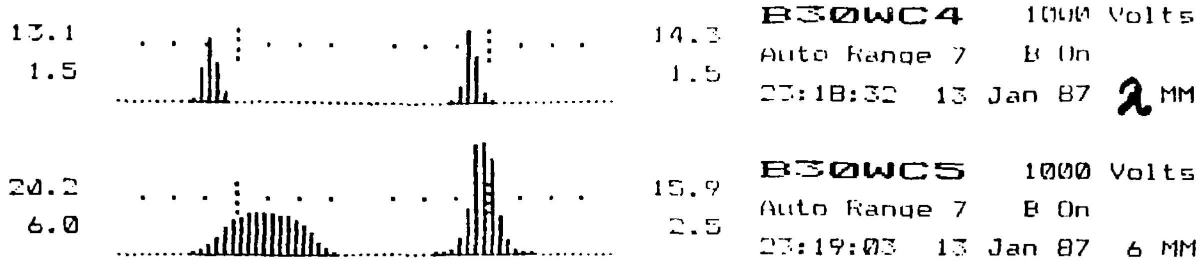
S1F3 500 Volts
Auto Range 7 B On
23:16:13 13 Jan 87 2 MM



B30WC1 500 Volts
Auto Range 5 B On
23:17:18 13 Jan 87 6 MM



B30WC3 500 Volts
Auto Range 6 B On
23:17:50 13 Jan 87 6 MM



3.2.4 WIRE CHAMBER PICTURES AND MAGNET CURRENTS OPTICS (II)

NAME	DATE	TIME	ENTRY	BEAM LINE
AR 12575 B30	13JAN87	22:50:54	8402	BEAM30

COMMENTS

AR 12575 B30 1.8 GEV/AMU AR+18 TO B30
E 594.0 S 586.6
RADIUS 599.85
XS1 FB. SPILL.
EXT PFW ACL 12575 EXT
WIRE 16 XM4WC
WIRE 36 S1F2WC
ALL STD F1 MAT IN.

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	202.49	400	1200
X	P2	P+	0.00	410	1210
X	S2	S+	7.71	400	1030
X	M2	S	-30.66	400	1190
X	S1	S+	106.54	400	1450
X	M3	S+	-15.21	400	1220
X	S1	P+	22.86	460	1690

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.29	5	0.00
X	S1	-2.94	0.00	5	0.00
X	S2	-0.15	3.05	5	0.00
X	M1	840.42	904.98	5	0.00
X	M2	2308.00	2313.35	5	0.00
X	M3	1859.67	1874.63	5	0.00
X	Q3A	1348.38	1347.46	5	0.00
X	Q3B	1322.85	1434.05	5	0.00
X	M3V	0.00	0.24	2001	0.00
X	M4V	0.00	3.18	2001	0.00
X	M4	1088.04	1091.55	2001	1088.04
X	M5	530.24	533.07	2001	530.24
X1	Q4A	2004.99	2025.38	2005	0.00
X1	Q4B	2068.99	2059.67	2005	0.00
X1	M5S	2.93	5.04	2001	2.93
X	Q4A	0.00	3.48	5	0.00
X	Q4B	0.00	3.48	5	0.00
S1	M3	289.30	293.15	2001	289.30
S1	M4	2981.59	2980.80	2005	1199.99
S1	M5	1151.44	1137.20	2005	999.76
S1	M6	422.80	426.26	2001	422.80
S1	Q7A	1428.58	1450.20	2005	0.00
S1	Q7B	1572.65	1587.72	2005	0.00
S1	M6S	50.85	51.98	1	50.85
S1	M7	44.45	48.88	2001	44.45
B30	M2	0.00	1600.39	2001	0.00
B30	M3	0.00	0.00	2001	0.00
B30	Q4A	0.00	0.00	2001	0.00
B30	Q4B	0.00	0.00	2001	0.00
B30	Q1	899.00	899.00		
B30	Q2	770.40	770.40		
B30	Q3A/B	1251.60	1251.60		
B30	Q4A/B	2632.80	2632.80		

OPTICS (II)

3.2.5 Beam 30 Focal Points (I)

Standard Optics

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	S1F2WC	1.65	0.50	-21.4
F3	S1F3WC	0.44	0.65	1.9
F4	B30WC2	1.16	0.33	-3.8
F5B	B30WC5	0.75	0.98	1.3

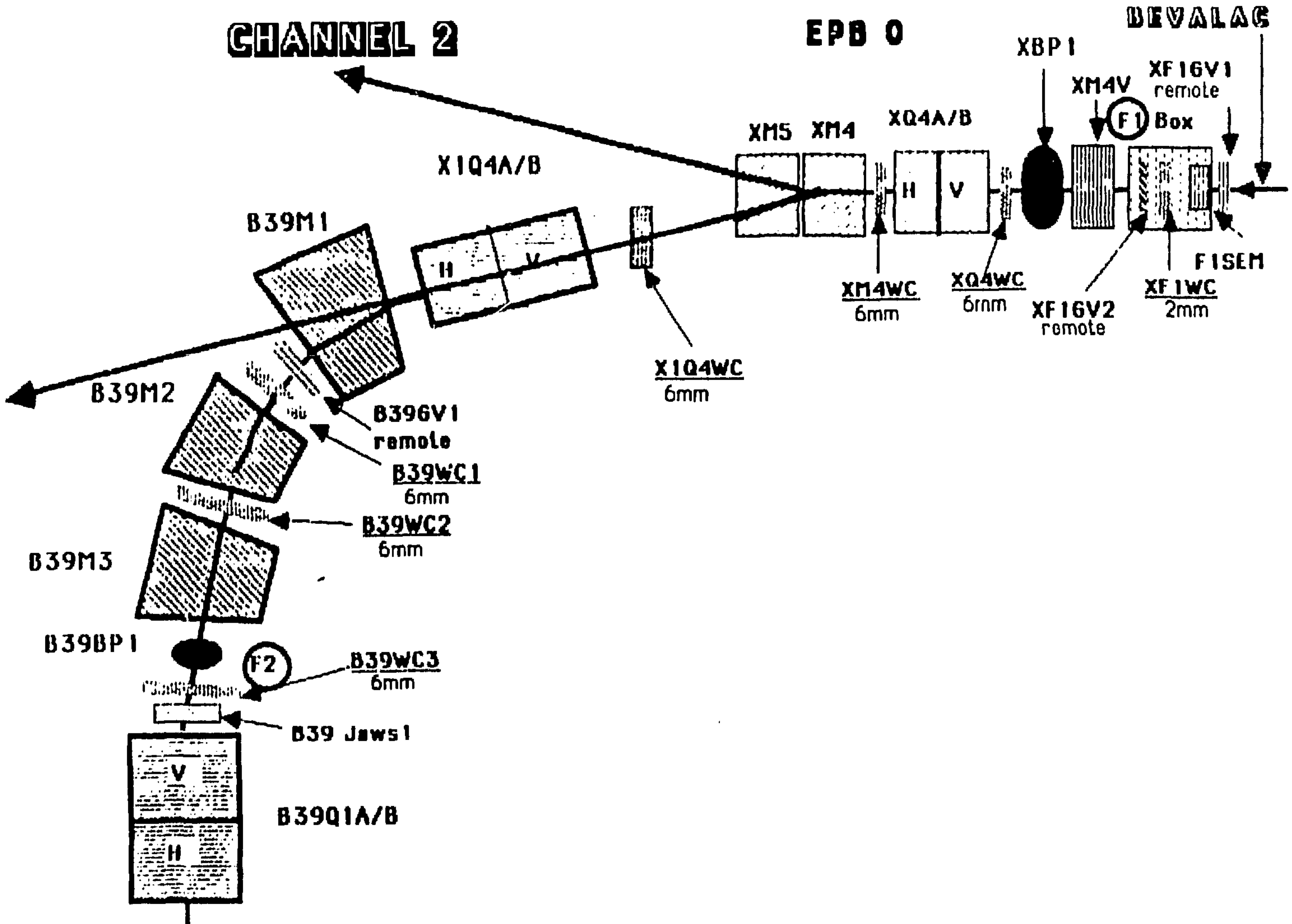
Beam 30 Focal Points (II)

High Rigidity and Short Focal Length (F5) Optics

Focal Point	Location	Horizational Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	S1F2WC	1.65	0.50	-21.4
F3	S1F3WC	0.44	0.65	1.9
F4	No Focal Point	-	-	-
F5A	B30WC4	0.30	0.46	-2.1

3.3 Beam 39

BEAM 39



CHANNEL 2
EPB 0
BEVALAC
XBP1
XM4V
XF16V1
remote
F1
Box
XM5
XM4
XQ4A/B
H
V
X1Q4A/B
B39M1
XM4WC
6mm
XQ4WC
6mm
XF16V2
remote
XF1WC
2mm
F1SEM
X1Q4WC
6mm
B39M2
B396V1
remote
B39WC1
6mm
B39WC2
6mm
B39M3
B39BP1
F2
B39WC3
6mm
B39 Jaws1
B39Q1A/B

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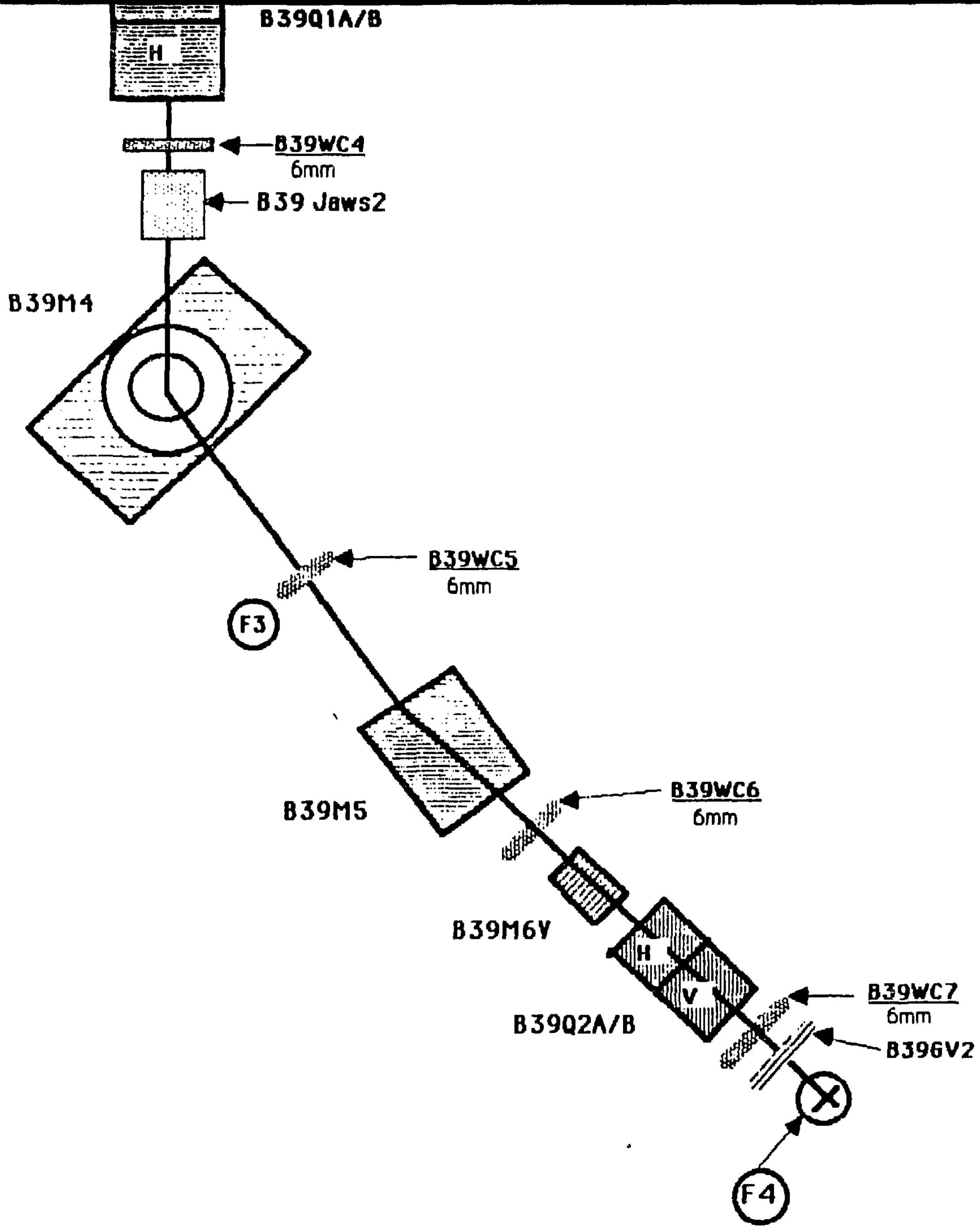

B39Q1A/B
H
B39WC4
6mm
B39 Jaws2
B39M4
B39WC5
6mm
F3
B39M5
B39WC6
6mm
B39M6V
H
V
B39Q2A/B
B39WC7
6mm
B396V2
F4

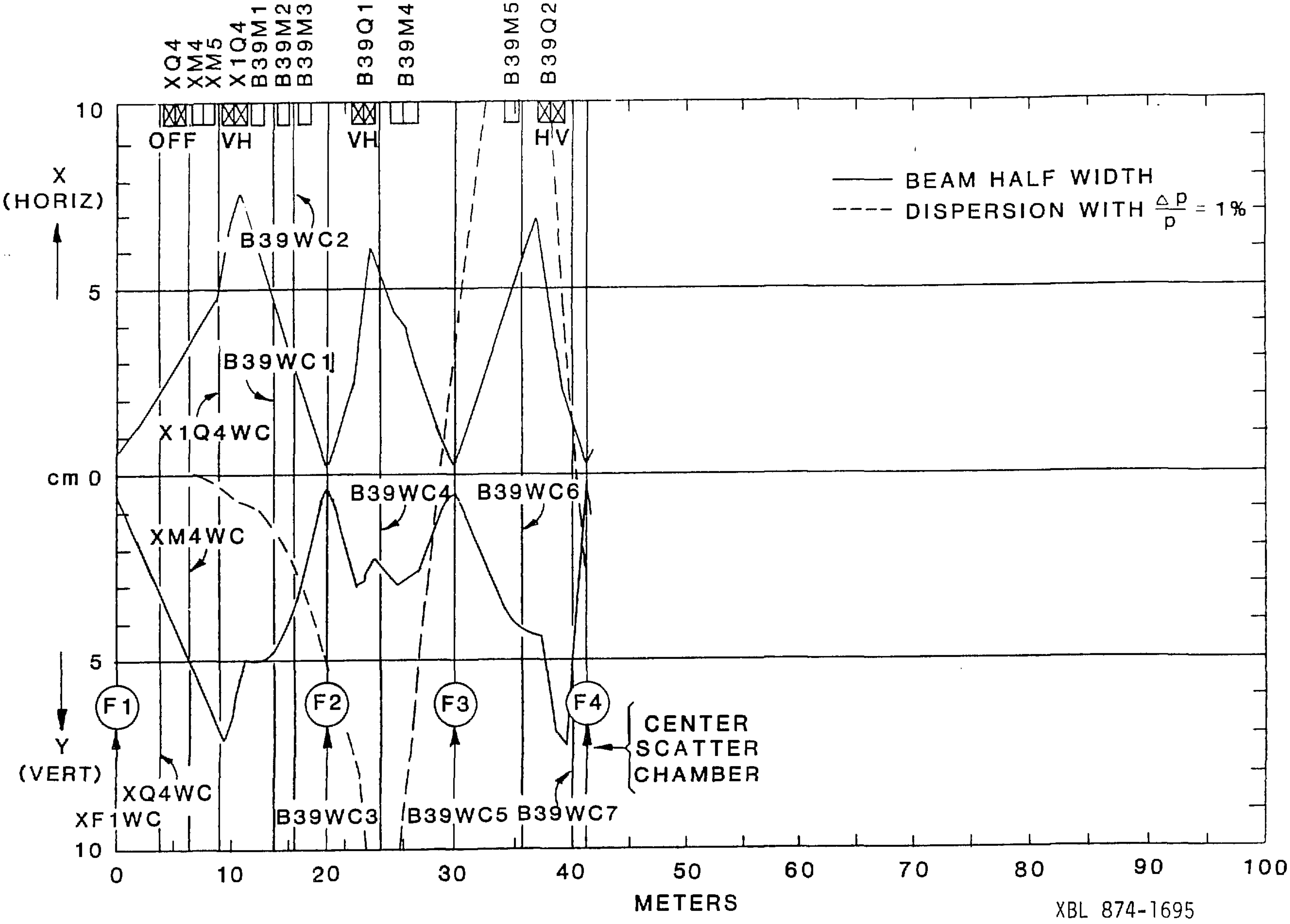
XBL 874-1703

3.3.2 Beam 39 Magnet Parameters

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
(F1)-XF1WC	-								
--- XQ4WC	4.000								
	0.221								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
--- XM4WC	0.220								
	0.242								
XM4	1.036			-16.88	11.37	5.222	0	5.222	6-1/8x18x36C
	0.173								
XM5	1.080			-13.50	14.22	4.351	-5.222	9.522	6-1/8x29x36H
--- X1Q4WC	0.282								
	0.235								
X1Q4A	0.884	-144	0.1046						8QN32
	0.284								
X1Q4B	0.884	+147	0.1046						8QB32
	0.259								
B39M1	1.036			-64.67	2.969	20.0	10.0	10.0	8x16x36C
--- B39WC1	0.774								
	0.394								
B39M2	1.036			-64.67	2.969	20.0	10.0	10.0	8x16x36C
--- B39WC2	0.274								
	0.540								
B39M3	1.080			-68.41	2.807	22.036	11.018	11.018	8x18x36HPH
(F2)-B39WC3	1.958								
	2.428								

Beam 39 Magnet Parameters (cont.)

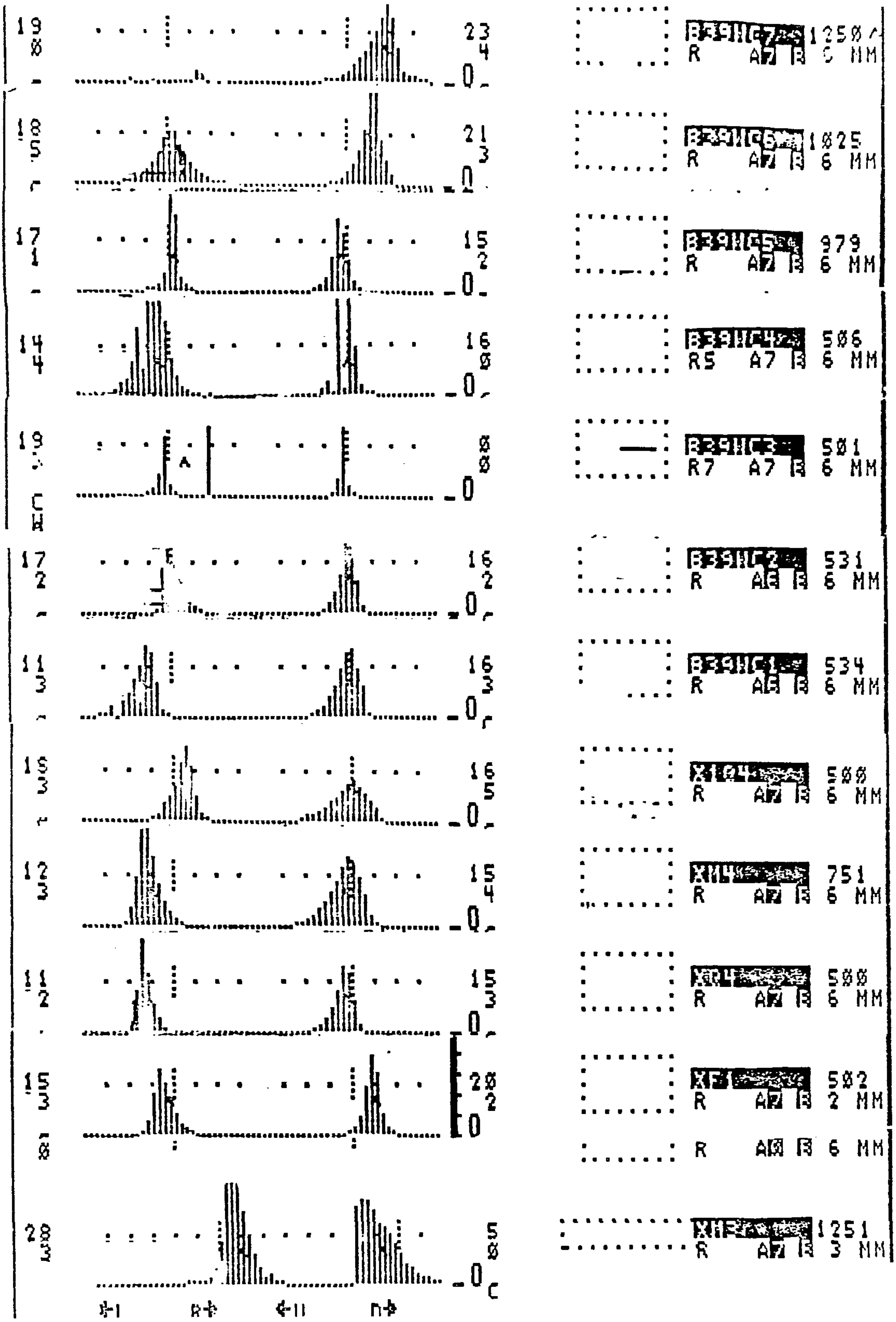
Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
B39Q1A	0.734	-95	0.1571						12QB24
	0.142								
B39Q1B	0.734	+95	0.1571						12QB24
--- B39WC4	0.220								
	1.753								
B39M4	1.872			-89.50	2.145	50.0	25.0	25.0	7-7/16x63H
(F3)-B39WC5	3.115								
	4.372								
B39M5	1.093			-75.17	2.554	24.5	12.25	12.25	6x18x36LPH
--- B39WC6	0.270								
	1.959								
B39Q2A	0.882	+100	0.1016						HP8Q32
	0.160								
B39Q2B	0.882	-100	0.1016						HP8Q32
--- B39WC7	0.500								
(F4)-B39CSC	1.675								



XBL 874-1695

SEC 3.3.3 BEAM 39

65/66



3.3.4 WIRE CHAMBER PICTURES AND CURRENTS

<u>Note</u>: The first few magnets in this line would be better tuned as shown in Sec. 3.7.4. This tune is not optimized horizontally.

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT 39	4DEC85	17:51:07	0	BEAM39

COMMENTS

NE2263 B39 130 MEV 20NE10
E 594.0 S 586.6
RADIUS 602.5

PFW ACL INJECT,VMODE ON,EXT PFW OFF
15 G TW
WIRE 15 AT F1
ALL MATERIAL OUT AT F1

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	39.87	400	1680
X	P2	P+	39.48	400	1510
X	S2	S+	291.31	470	1300
X	S1	S+	156.49	440	1060
X	S2	P+	30.85	450	1100
X	M3	S	6.92	440	1020

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.00	5	0.00
X	S1	0.00	0.44	5	0.00
X	S2	0.00	1.83	5	0.00
X	M1	133.48	139.92	5	0.00
X	M2	558.05	545.95	2005	0.00
X	M3	486.34	466.93	5	0.00
X	Q3A	229.98	195.47	5	0.00
X	Q3B	193.64	200.05	5	0.00
X	M3V	30.94	31.63	2003	30.94
X	M4V	0.02	0.12	1	0.02
X	M4	174.23	173.03	2001	174.23
X	M5	75.09	77.38	2001	75.09
X1	Q4A	279.44	323.51	5	0.00
X1	Q4B	408.57	470.54	5	0.00
X1	M5S	0.00	0.41	1	0.00
X	Q4A	0.00	1.16	5	0.00
X	Q4B	0.00	3.48	5	0.00
B39	M1	1057.22	1079.53	1	1057.22
B39	M2	1057.18	1055.64	2005	1057.18
B39	M3	911.96	945.97	1	911.96
B39	Q1A	1181.60	1181.60		
B39	Q1B	1113.30	1113.30		
B39	M4	879.00	879.00		
B39	M5	438.80	438.80		
B39	Q2A	292.20	292.20		
B39	Q2B	383.40	383.40		
B39	M6V	48.48	48.48		

DATA FOR ENERGY CALCULATION

INJECTION:HILAC LOCAL

PARTICLE: Ne 2S FREQ : 246
MASS NUM: 20 2S FIELD: 40
CHARGE : 10 K.ENERGY: 163
INFLECTOR H.V: −19

EXTRACTION: PFW: ON: OFF: ✓

FIELD: 2263 P1 CUR: 4
FREQ: 1210 P2 CUR: 3
BEAM RAD:

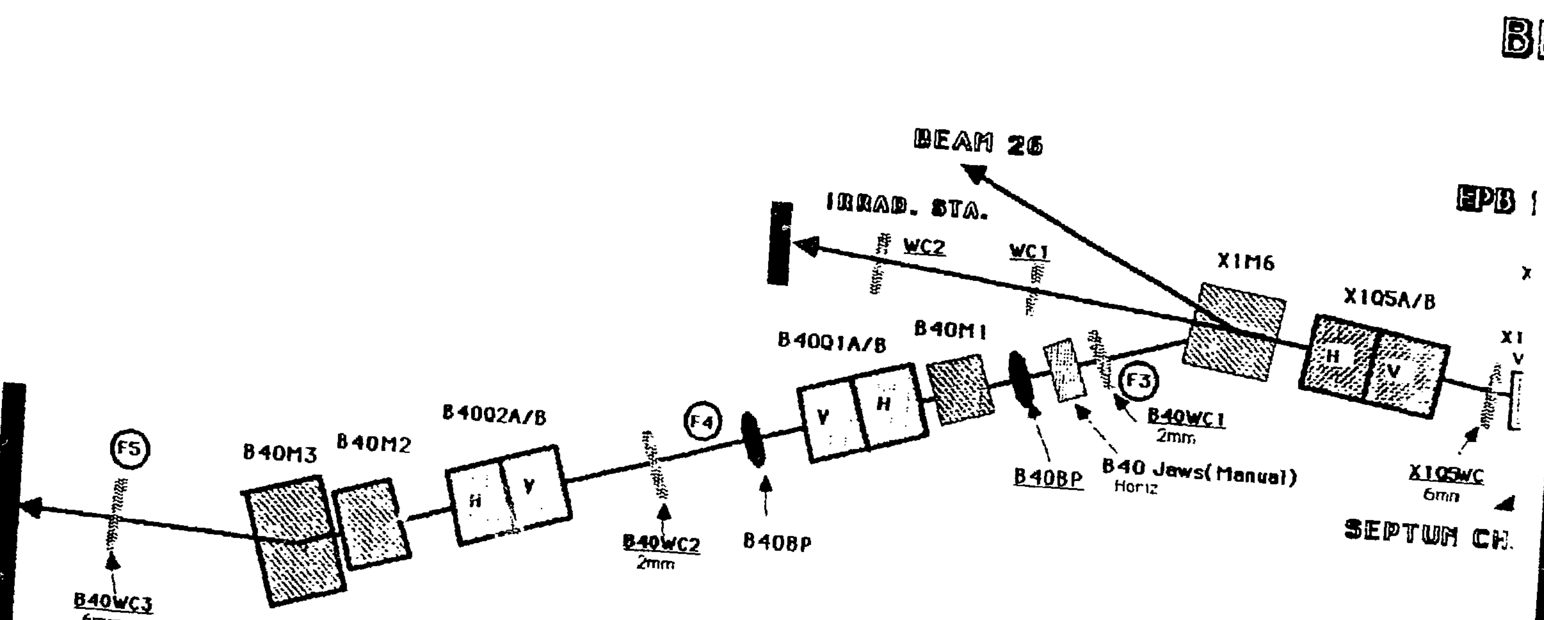
	RADIUS	CURRENT	TAIL WAG	
M1:	594	140	RISE:	16 E-
M2:	586.6	546	TIME:	m-
M3:	------	467	S1 ON:	OFF
			S2 ON:	OFF

STD MATERIAL AT F1: IN: OUT: ✓

3.3.5 Beam 39 Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	B39WC3	0.49	0.62	-54.2
F3	B39WC5	0.56	0.95	25.6
F4	Center Scatter Chamber (CSC)	0.46	0.23	-38.0

3.4 Beam 40


BEAM 26
IRRAD. STA.
WC2
WC1
X1M6
X1Q5A/B
EPB
B40Q1A/B
B40M1
F3
B40WC1
2mm
B40BP
B40 Jaws(Manual)
Horiz
X1Q5WC
6mm
SEPTUM CH.
B40Q2A/B
F4
B40M3
B40M2
F5
B40WC2
2mm
B40BP
B40WC3
6mm

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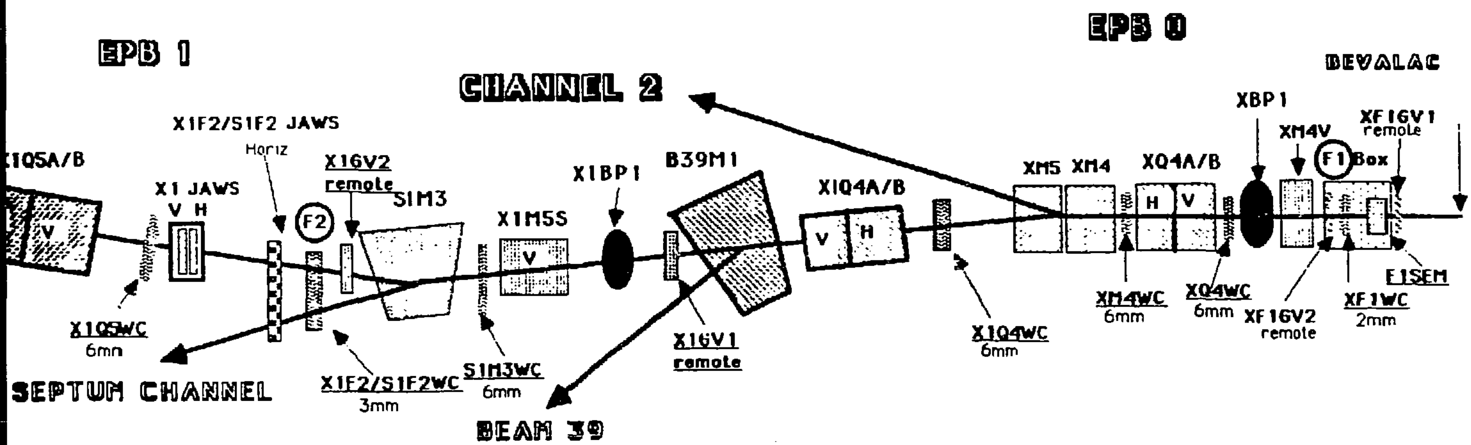
BEAM 40



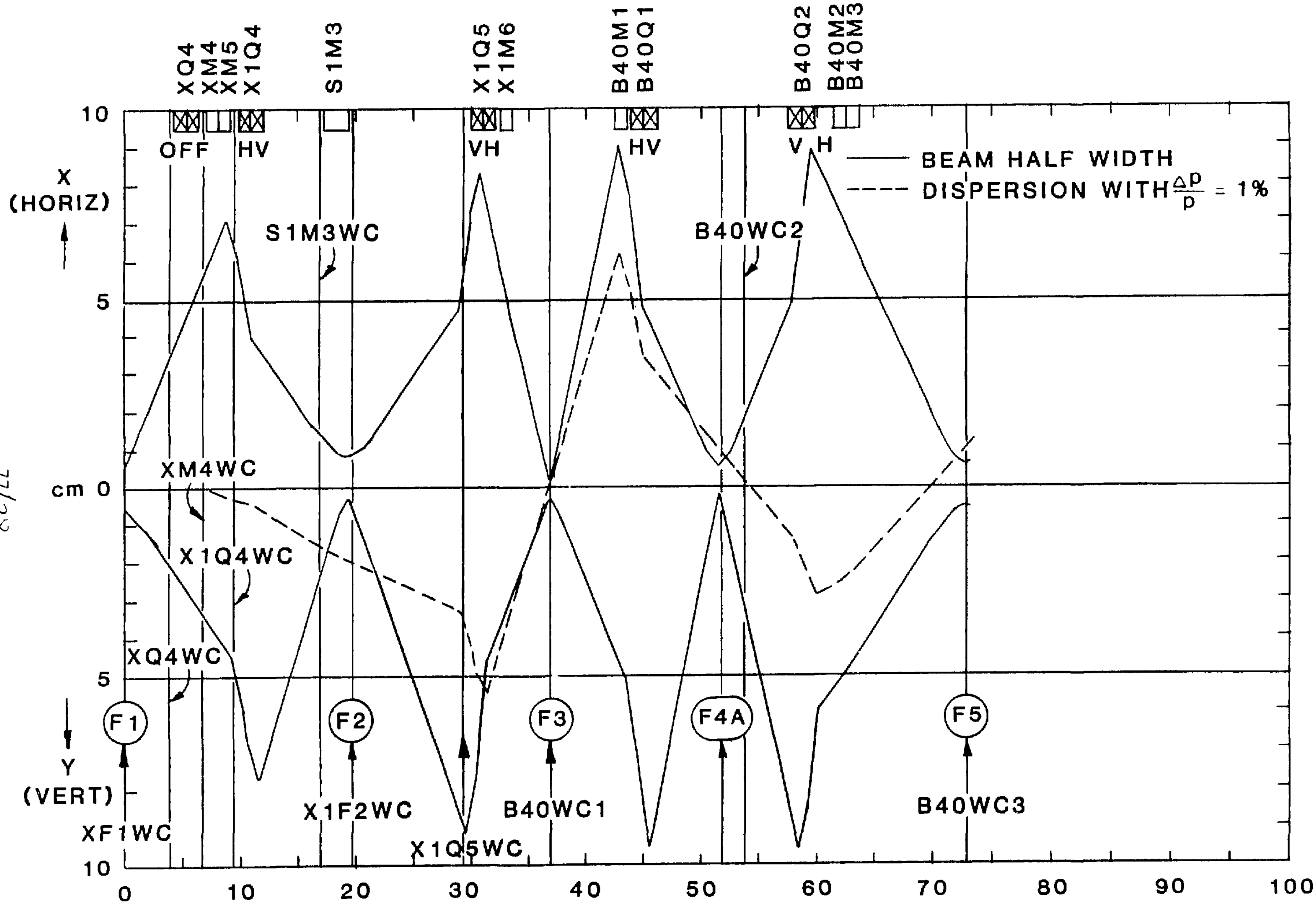
XBL 874-1708

3.4.2 Beam 40 Magnet Parameters

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
(F1)-XF1WC	-								
--- XQ4WC	4.000								
	0.221								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
--- XM4WC	0.220								
	0.242								
XM4	1.036			-16.88	11.37	5.222	0	5.222	6-1/8x18x36C
	0.173								
XM5	1.080			-13.50	14.22	4.351	-5.222	9.522	6-1/8x29x36H
--- X1Q4WC	0.282								
	0.235								
X1Q4A	0.884	+144	0.1046						8QN32
	0.284								
X1Q4B	0.884	-147	0.1046						8QB32
--- S1M3WC	4.862								
	0.340								
S1M3	2.250			4.51	42.58	3.028	0	3.028	4.38x15x84H
(F2)-X1F2WC	0.770								
--- X1Q5WC	9.480								
	0.240								
X1Q5A	0.884	-144	0.1046						8QN32
	0.306								
X1Q5B	0.884	+144	0.1046						8QN32
	0.361								

Beam 40 Magnet Parameters (cont.)

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
X1M6	1.036			-20.05	9.577	6.2	0	6.2	6x16x36C
(F3)-B40WC1	4.318								
	4.940								
B40M1	1.036			20.05	9.577	6.2	3.1	3.1	6x16x36C
	0.335								
B40Q1A	0.884	+144	0.1046						8QN32
	0.082								
B40Q1B	0.884	-144	0.1046						8QN32
(F4A)	6.453								
(F4B)-B40WC2	1.817								
	4.625								
B40Q2A	0.884	-147	0.1046						8QB32
	0.132								
B40Q2B	0.884	+147	0.1046						8QB32
	1.087								
B40M2	1.036			17.78	10.80	5.5	2.75	2.75	8x16x36C
	0.173								
B40M3	1.056			17.44	11.01	5.5	-2.75	8.25	8.12x40x36H
(F5)-B40WC3	9.264								



XBL 874-1696

SEC 3.4.3 BEAM 40

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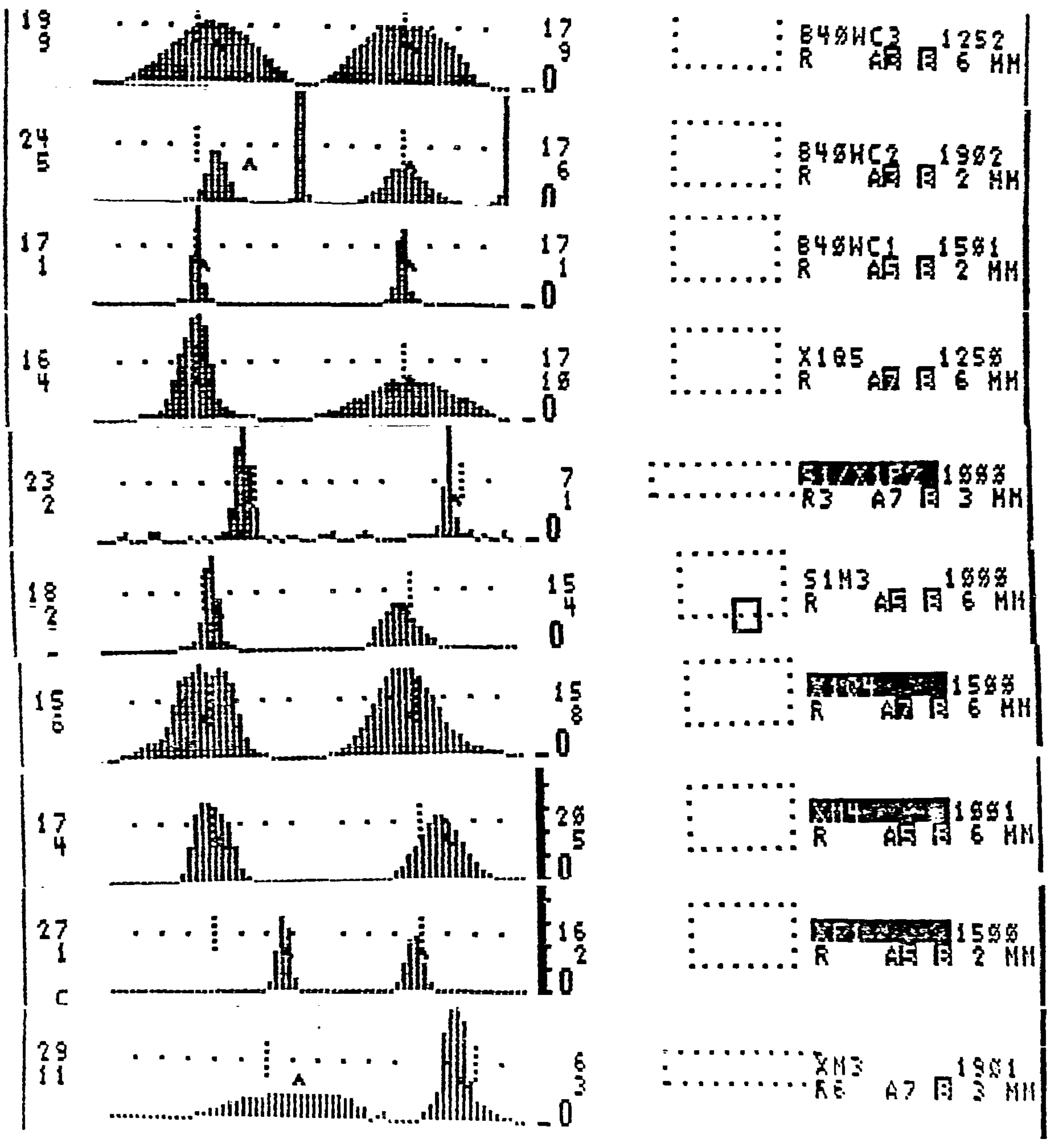


3.4.4 WIRE CHAMBER PICTURES AND MAGNET CURRENTS

22APR86 EPB ACL PRINT 22:47:42 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT	B40G22APR86	22:47:42	0	BEAM40

COMMENTS
U28 12.5B40G RADIUS =599.8
E 594.00 S 586.60
XS1 COMPUTER RAMP SPILL

EXT PFW "12575 EXT"
ALL MATERIAL OUT AT F1

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	206.92	410	1200
X	P2	P+	-0.71	410	1210
X	S2	S+	7.71	400	1030
X	M2	S	-30.66	400	1190
X	S1	S+	179.03	400	1450
X	M3	S+	-15.21	400	1220
X	S1	P+	71.69	460	1690

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.88	5	0.00
X	P2	0.00	0.00	5	0.00
X	S1	-3.00	0.22	5	0.00
X	S2	-0.18	3.42	5	0.00
X	M1	999.83	1081.11	5	0.00
X	M2	2301.87	2300.77	5	0.00
X	M3	1851.63	1876.61	5	0.00
X	Q3A	1336.21	1343.43	5	0.00
X	Q3B	1310.30	1422.33	5	0.00
X	M3V	17.28	16.85	2001	17.28
X	M4V	0.24	1.34	1	0.24
X	M4	1213.03	1212.60	2001	1213.03
X	M5	485.34	490.08	2001	485.34
X1	Q4A	2000.15	2037.82	5	0.00
X1	Q4B	2084.75	2048.12	5	0.00
X1	M5S	30.00	30.06	1	30.00
S1	M3	304.98	308.54	2003	304.98
X1	Q5A	2210.95	2201.56	2001	2210.95
X1	Q5B	2413.71	2385.73	2001	2413.71
X1	M6	1615.39	1589.11	2001	1615.39
X	Q4A	0.00	0.00	5	0.00
X	Q4B	0.00	0.00	5	0.00
B40	M1	1646.92	1671.71	1	1646.92
B40	Q1A	2940.83	2988.28	1	2940.83
B40	Q1B	2835.49	2909.13	1	2835.49
B40	Q2A	1036.29	1030.41	1	1036.29
B40	Q2B	634.27	648.82	1	634.27
B40	M2+3	1352.47	3.91	1	1352.47

DATA FOR ENERGY CALCULATION

INJECTION: HILAC ✓LOCAL

PARTICLE: U 2S FREQ : 330.6
MASS NUM: 238 2S FIELD: 945
CHARGE : 68 K.ENERGY:
INFLECTOR H.V: 52.5

EXTRACTION: PFW: (ON) 12.5 OFF:

FIELD: 12.575 F1 CUR:
FREQ: 2170320 P2 CUR:
BEAM RAD: 599.85

	RADIUS	CURRENT	TAIL WAG	
M1:		:	RISE:	GAUSS
M2:		:	TIME:	mSECS
M3:	-------	:	(S1 ON:)	OFF:
			S2 ON:	OFF:

Open Loop →

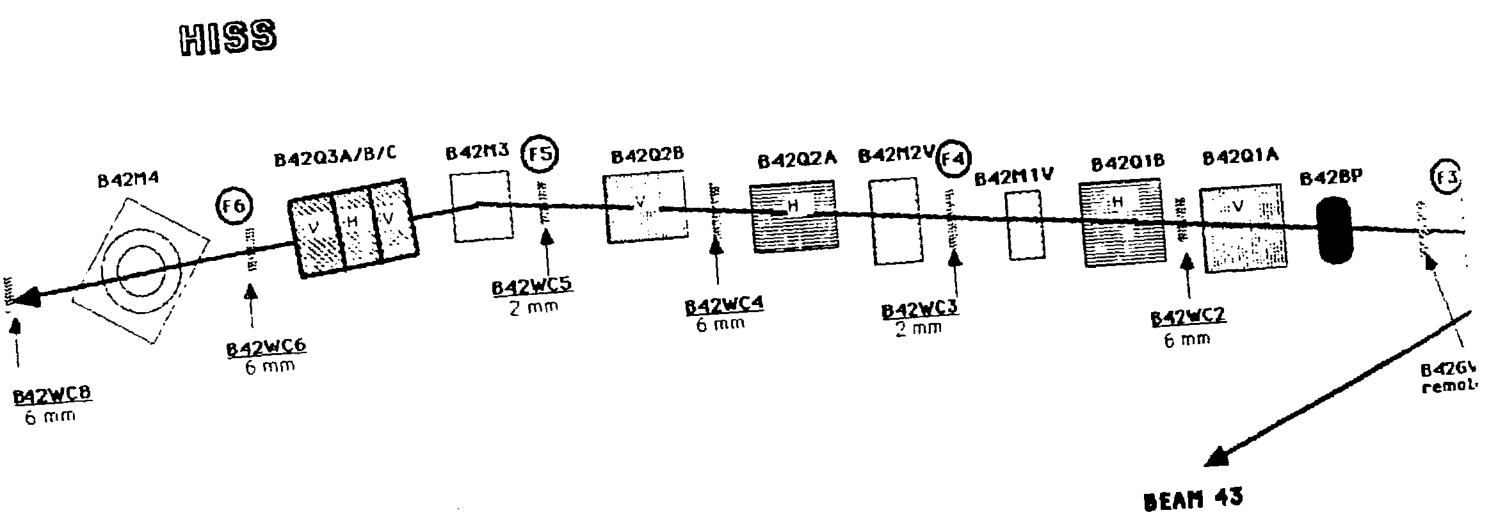
STD MATERIAL AT F1: IN: (OUT:)

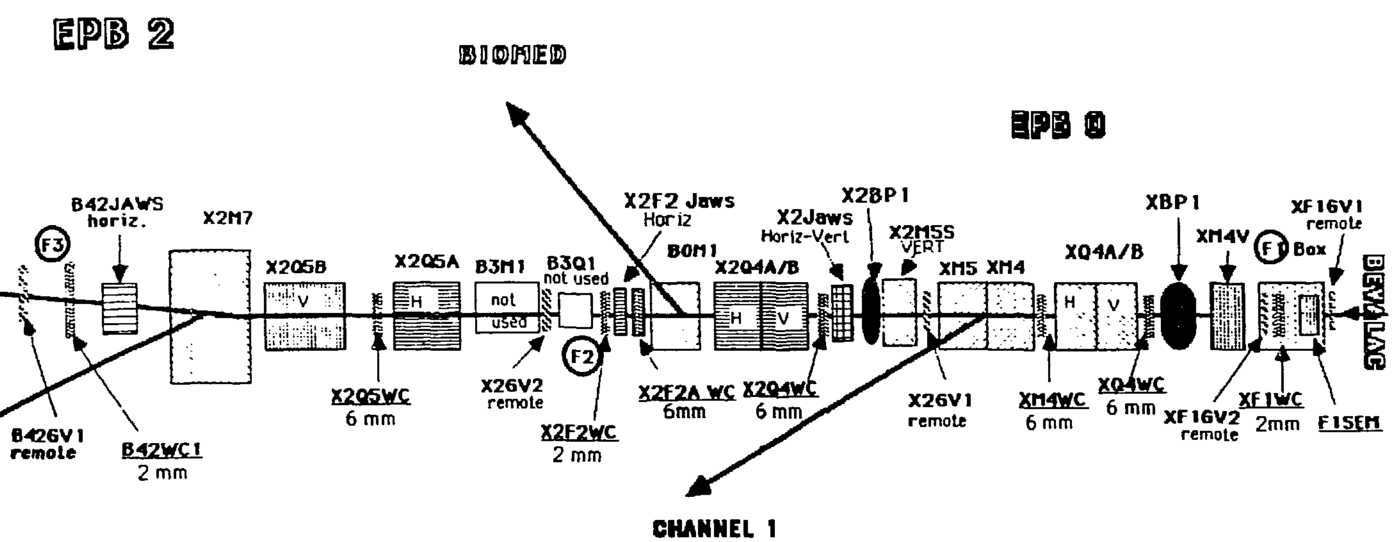
3.4.5 Beam 40 Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	X1F2WC	1.63	0.50	-19.4
F3	B40WC1	0.53	0.58	0.9
F4	71-1 2" upstream B40WC2	1.04	0.32	10.1
F5	B40WC3	1.09	0.97	9.1

3.5 Beam 42

BEAM 42


HISS
B42M4
B42Q3A/B/C
B42M3
B42Q2B
B42Q2A
B42M2V
B42M1V
B42Q1B
B42Q1A
B42BP
F6
F5
F4
F3
V
H
B42WC8
6 mm
B42WC6
6 mm
B42WC5
2 mm
B42WC4
6 mm
B42WC3
2 mm
B42WC2
6 mm
BEAM 43


EPB 2
BIOMED
EPB 0
B42JAWS
horiz.
X2M7
F3
X2Q5B
X2Q5A
B3M1
not
used
B3Q1
not used
X2F2 Jaws
Horiz
B0M1
X2Q4A/B
X2Jaws
Horiz-Vert
X2BP1
X2M5S
VERT
XM5
XM4
XQ4A/B
XBP1
XM4V
F1
Box
XF16V1
remote
BEVALAC
H
V
F2
B426V1
remote
B42WC1
2 mm
X2Q5WC
6 mm
X26V2
remote
X2F2WC
2 mm
X2F2A WC
6mm
X2Q4WC
6 mm
X26V1
remote
XM4WC
6 mm
XQ4WC
6 mm
XF16V2
remote
XF1WC
2mm
F1SEM
CHANNEL 1

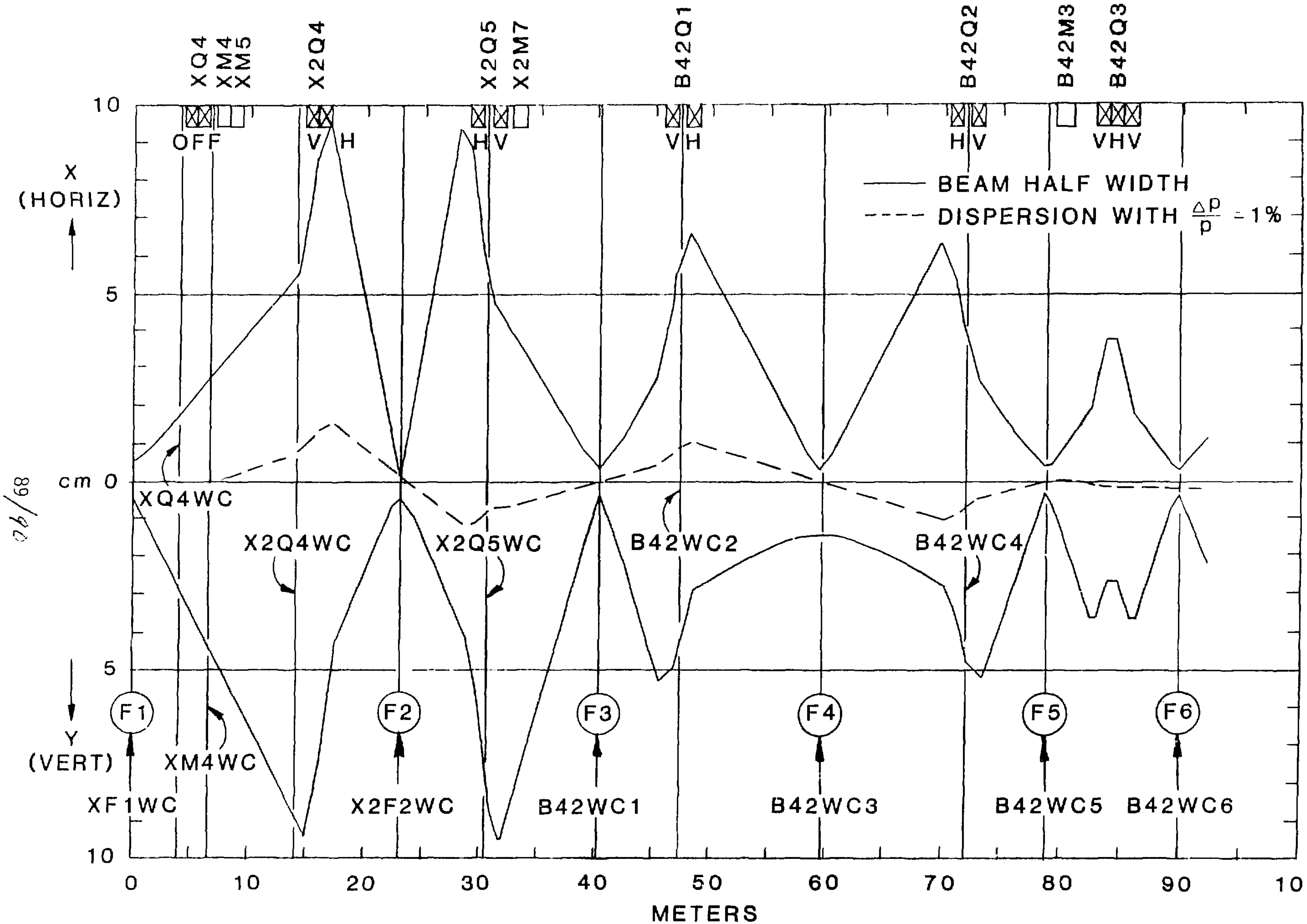
XBL 874-1707

3.5.2 Beam 42 (HISS) Magnet Parameters

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG·m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
(F1)-XF1WC	-								
--- XQ4WC	4.000								
	0.221								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
--- XM4WC	0.220								
	0.242								
XM4	1.036			11.46	16.75	3.545	0	3.545	6-1/8x18x36C
	0.173								
XM5	1.080			9.26	20.72	2.985	-3.545	6.529	6-1/8x29x36H
--- X2Q4WC	5.415								
	0.495								
X2Q4A	1.308	-138	0.1046						8QB48
	0.216								
X2Q4B	1.308	+138	0.1046						8QB48
(F2)-X2F2WC	5.675								
	5.566								
X2Q5A	0.882	+117	0.1016						LP8Q32
---X2Q5WC	0.504								
	0.504								
X2Q5B	0.882	-117	0.1016						LP8Q32
	0.504								
X2M7	1.036			14.88	12.91	4.6	6.0	-1.4	[illegible]x36C
(F3)-B42WC1	7.420								
	4.956								

Beam 42 Magnet Parameters (Cont.)

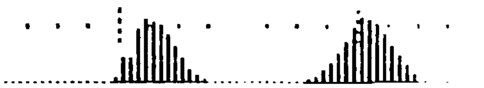
Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
B42Q1A	1.308	-138	0.1046						8QB48
---B42WC2	0.260								
	0.260								
B42Q1B	1.308	+138	0.1046						8QB48
(F4)-B42WC3	10.992								
	10.602								
B42Q2A	1.308	+138	0.1046						8QB48
---B42WC4	0.260								
	0.260								
B42Q2B	1.308	-138	0.1046						8QB48
(F5)-B42WC5	5.452								
	0.429								
B42M3	1.542			-16.30	11.78	7.5	3.75	3.75	8x18x60H
	1.689								
B42Q3A	0.490	-146	0.1046						8QB16
	0.939								
B42Q3B	0.884	+147	0.1046						8QB32
	0.939								
B42Q3C	0.490	-146	0.1046						8QB16
(F6)-B42WC6	3.693								
---B42CM4	2.250								



XBL 874-1697

SEC 3.5.3 BEAM 42

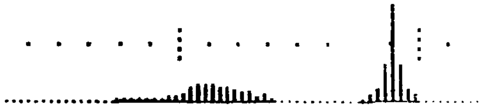
21.3
4.5



17.7
5.0

XM2 1000 Volts
Auto Range 3 B On
23:52:31 06 Feb 87 3 MM

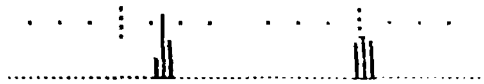
29.1
7.0



4.9
1.5

XM3 1500 Volts
Auto Range 6 B On
23:55:21 06 Feb 87 3 MM

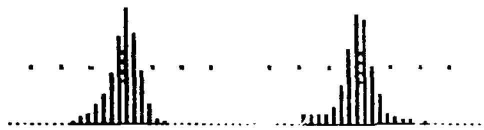
22.2
1.5



17.0
1.5

XF1 501 Volts
Auto Range 1 B On
23:56:17 06 Feb 87 2 MM

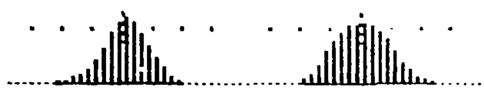
16.6
3.0



16.3
3.0

XM4 500 Volts
Auto Range 1 B On
23:56:50 06 Feb 87 6 MM

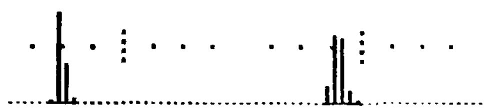
16.9
5.0



16.7
5.5

X2Q4 1000 Volts
Auto Range 3 B On
23:57:16 06 Feb 87 6 MM

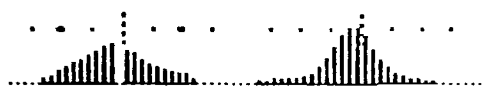
8.3
1.0



13.5
1.5

X2F2 1001 Volts
Auto Range 2 B On
23:58:35 06 Feb 87 2 MM

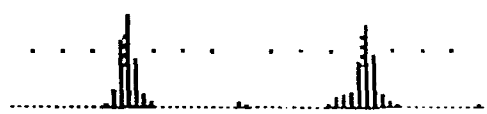
15.7
8.5



15.2
5.0

X2Q5 1000 Volts
Manual Range 5 B On
23:59:40 06 Feb 87 6 MM

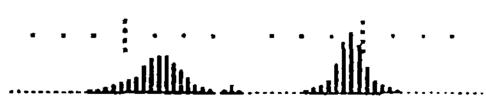
17.1
1.5



16.8
2.0

B42WC1 1000 Volts
Auto Range 1 B On
00:01:24 07 Feb 87 2 MM

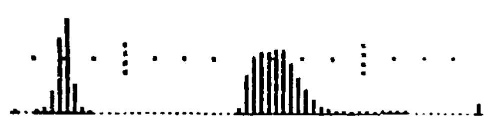
21.4
5.0



15.1
3.5

B42WC2 1000 Volts
Auto Range 3 B On
00:01:59 07 Feb 87 6 MM

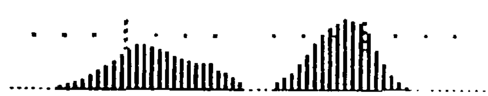
9.0
2.0



4.9
4.0

B42WC3 1500 Volts
Manual Range 2 B On
00:03:06 07 Feb 87 2 MM

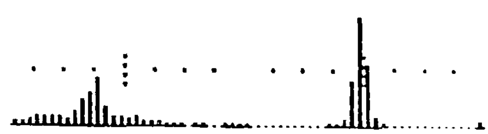
20.7
9.0



13.6
6.0

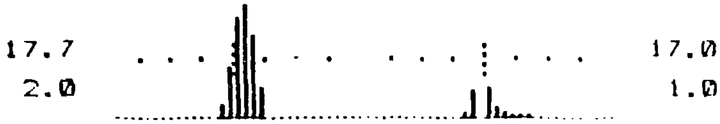
B42WC4 1250 Volts
Auto Range 3 B On
00:03:50 07 Feb 87 6 MM

13.4
2.5



16.0
1.5

B42WC5 1000 Volts
Manual Range 1 B On
00:05:12 07 Feb 87 7 MM



B42WC6 1000 Volts
Auto Range 1 B On
00:06:02 07 Feb 87 6 MM

B42WC8 2350 Volts
Auto Range 5 B On
00:07:16 07 Feb 87 6 MM

3.5.4 WIRE CHAMBER PICTURES AND MAGNET CURRENTS

ZHEP9'   EPB ACL PRINT   19:13:30   PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
J 7650 B42	6FEB87	23:03:20	08437	BEAM42

COMMENTS

7650 B42   104E MEV/AMU C+6 TO B42
E 594.0   S 586.58
RADIUS 599.5
XS1 FEEDBACK SPILL
EXT PFW ACL 7650 EXT
Focus on WC8 with Q3A/B/C

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	82.52	400	1680
X	P2	P+	29.01	400	1510
X	S2	S+	291.31	470	1300
X	S1	S+	125.66	440	1150
X	S2	P+	30.84	450	1100
X	M3	S+	-9.77	400	1220
X	S1	P+	15.47	400	1240
X	M2	S+	-17.61	420	1120

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.29	5	0.00
X	S1	0.00	1.32	5	0.00
X	S2	0.00	3.05	5	0.00
X	M1	540.81	587.54	5	0.00
X	M2	1609.69	1621.48	2005	0.00
X	M3	1237.68	1256.35	5	0.00
X	Q3A	809.16	803.37	5	0.00
X	Q3B	813.39	682.27	5	0.00
X	M3V	12.46	12.09	2001	12.46
X	M4V	0.03	1.47	1	0.03
X	M4	-472.59	-476.70	2001	-472.59
X	M5	203.71	206.74	2001	203.71
X	Q4A	0.00	3.48	5	0.00
X	Q4B	0.00	3.48	5	0.00
X2	M5S	29.95	26.91	2001	29.95
X2	Q4A	769.78	770.15	2005	0.00
X2	Q4B	854.70	840.50	2005	0.00
B0	M1	0.00	48.85	1001	0.00
B3	M1	0.00	0.00	1	0.00
X2	Q5A	648.14	647.04	2001	648.14
X2	Q5B	574.96	578.16	2001	574.96
X2	M7	782.11	791.99	2001	782.11
B42	Q1A	918.78	896.37	2001	918.78
B42	Q1B	773.84	778.65	2001	773.84
B42	M1V	58.09	63.86	2001	58.09
B42	Q2A	795.39	797.12	2001	795.39
B42	Q2B	907.63	917.15	2001	907.63
B42	M2V	0.00	3.76	2001	0.00
B42	M3	895.60	910.99	2001	895.60
B42	Q3A+C	1465.90	1452.15	2001	1465.90
B42	Q3B	1432.66	1418.47	2001	1432.66

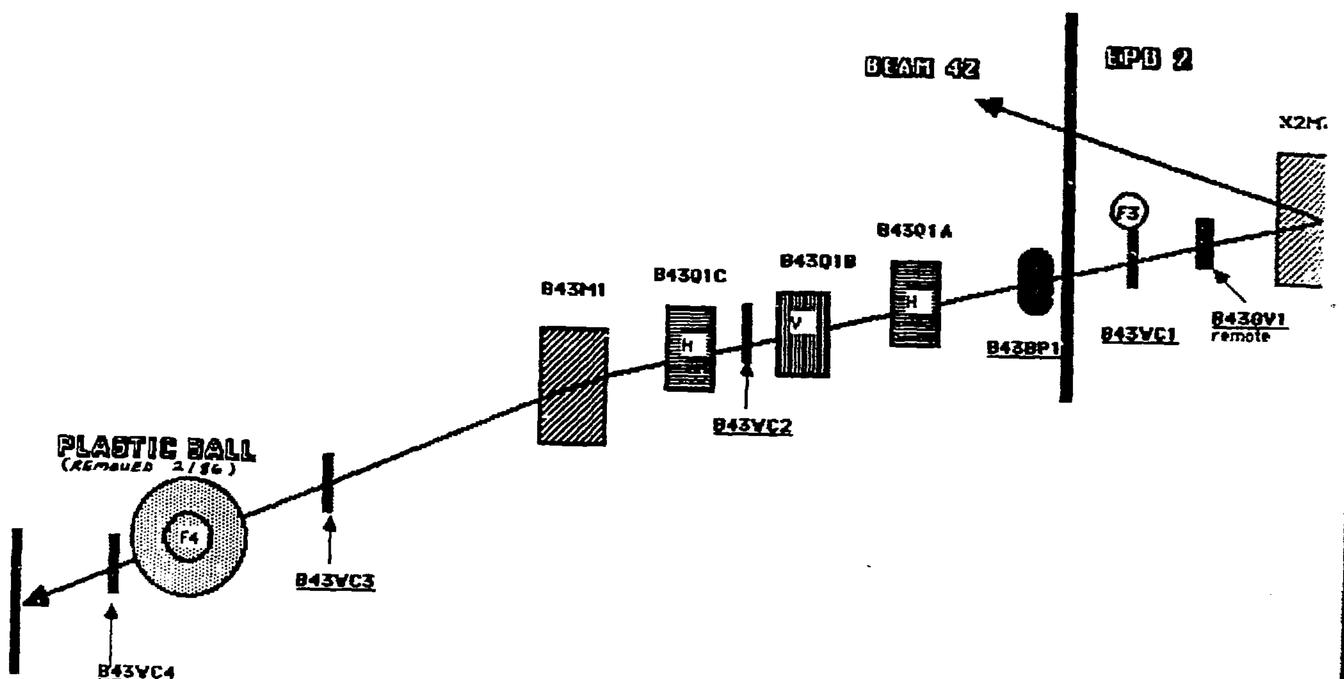
3.5.5 Beam 42 (HISS) Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	X51WC	1.0	1.0	0.0
F2	X2F2WC	0.22	0.88	2.0
F3	B42WC1	0.70	0.60	0.05
F4	B42WC3	0.62	0.28	0.03
F5	B42WC5	0.77	0.68	-0.14
F6	B42WC6	0.77	0.69	-1.5

3.6 Beam 13

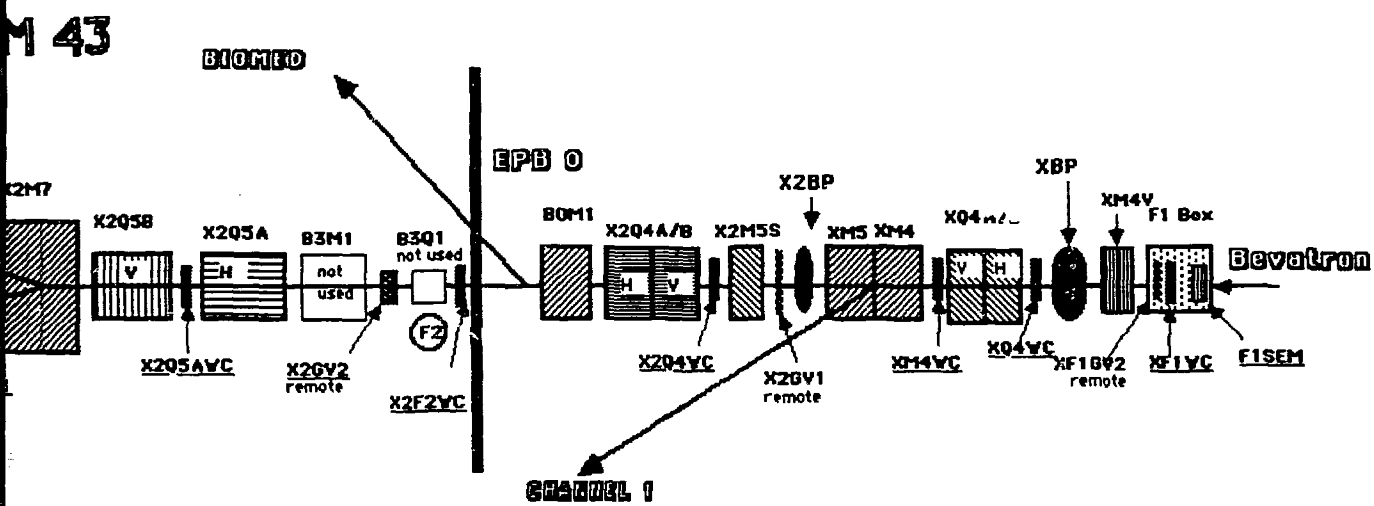
3.

BEAM



BEAM 42
EPB 2
X2M
B43Q1A
B43Q1B
B43Q1C
B43M1
H
V
H
B43BP1
B43VC1
B43QV1
remote
B43VC2
PLASTIC BALL
(REMOVED 2/86)
F3
F4
B43VC3
B43VC4

3.6.1 BEAM 43 SCHEMATIC



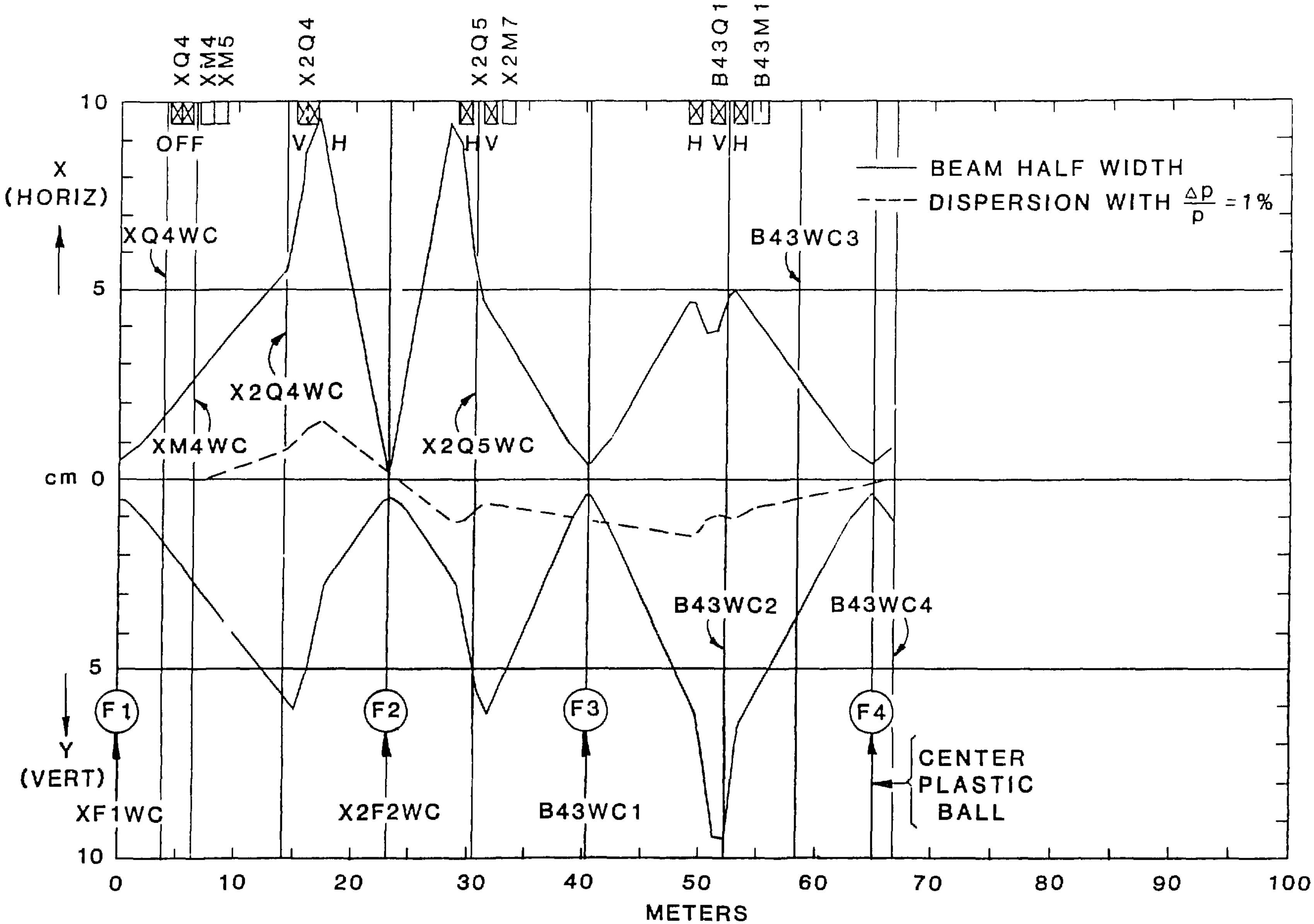
XBL 874-1709

3.6.2 Beam 43 Magnet Parameters

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
(F1)-XF1WC	-								
---XQ4WC	4.000								
	0.221								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
---XM4WC	0.220								
	0.242								
XM4	1.036			11.46	16.75	3.545	0	3.545	6-1/8x18x36C
	0.173								
XM5	1.080			9.26	20.72	2.985	-3.545	6.529	6-1/8x29x36H
---X2Q4WC	5.415								
	0.495								
X2Q4A	1.308	-138	0.1046						8QB48
	0.216								
X2Q4B	1.308	+138	0.1046						8QB48
(F2)-X2F2WC	5.675								
	5.566								
X2Q5A	0.882	+117	0.1016						LP8Q32
---X2Q5WC	0.504								
	0.504								
X2Q5B	0.882	-117	0.1016						LP8Q32
	0.504								
X2M7	1.036			-9.70	19.79	3.0	-6.0	3.0	8x16x36C
(F3)-B43WC1	7.430								
	9.888								

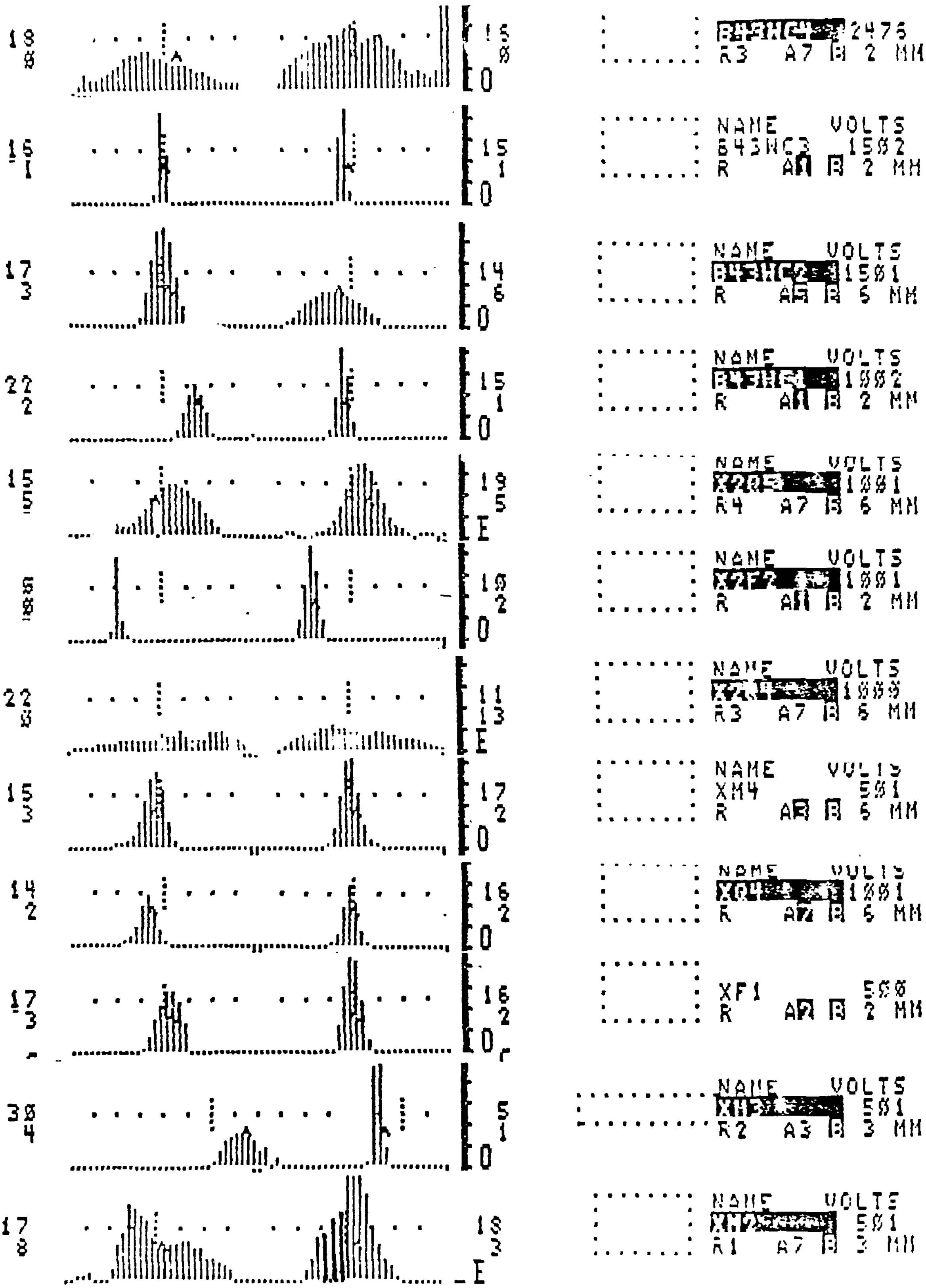
Beam 43 Magnet Parameters (Cont.)

Beam Line Element	Effective Length (m)	Quadrupole Magnet: Max. Gradient (kG/m)	Quadrupole Magnet: Pole tip Radius (m)	Dipole Magnet: Field (192 kG-m) (kG)	Dipole Magnet: Bend Radius (m)	Dipole Magnet: Bend Angle (deg.)	Dipole Magnet: Incoming Edge Angle (deg.)	Dipole Magnet: Outgoing Edge Angle (deg.)	Magnet Type (in)
B43Q1A	0.493	+139	0.1046						8QN16
	0.978								
B43Q1B	0.884	-147	0.1046						8QB32
---B43WC2	0.230								
	0.748								
B43Q1C	0.493	+146	0.1046						80B16
	0.548								
B43M1	1.542			-17.04	11.27	7.84	3.92	3.92	8x18x60H
---B43WC3	3.000								
(F4)-B43CPB	6.414								
---B43WC4	1.710								



XBL 874-1698

SEC 3.6.3 BEAM 43



3.6.4 WIRE CHAMBER PICTURES AND CURRENTS

4NOV85 EPB ACL PRINT 22:29:08 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
NE 5666 B43	4NOV85	22:28:26	7754	BEAM43

COMMENTS

NE 5666 B43 E 594.00 S 526.58
TUNE WITH NEW EPB0
BEAM AT WIRE 16 AT F1
RADIUS 599
XS1 FEEDBACK SPILL
EXT PPW ACL 5666SPLR EXT
PRELIMINARY TUNE

PERTURBATION UNIT DATA

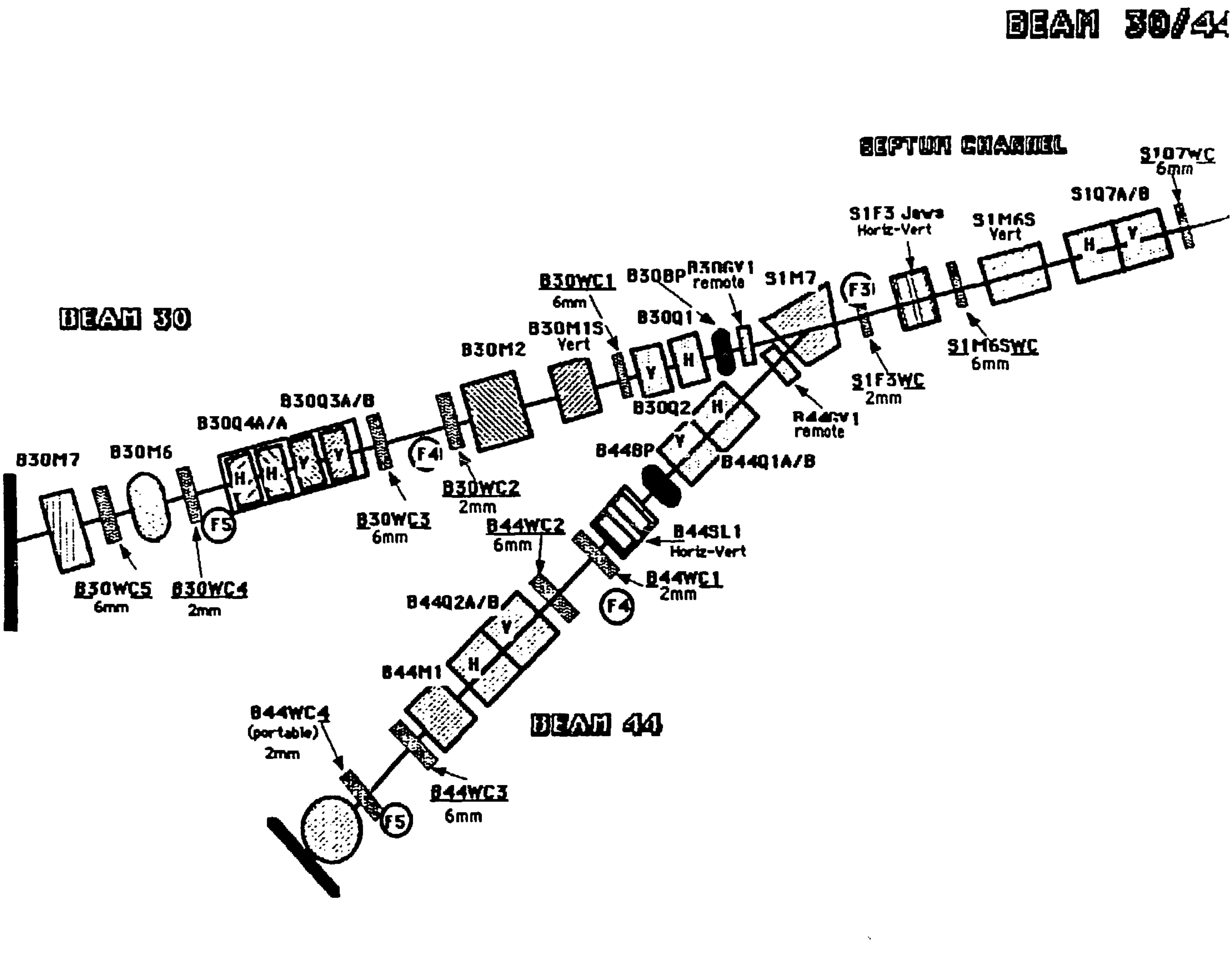
NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	96.62	400	1680
X	P2	P+	24.02	400	1510
X	S2	S+	291.31	470	1300
X	S1	S+	221.65	440	1150
X	S2	P+	30.85	450	1100
X	M3	S+	-20.40	400	1040
X	S1	P+	64.69	400	1240

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.88	5	0.00
X	P2	0.00	0.00	5	0.00
X	S1	0.00	0.44	5	0.00
X	S2	0.00	4.03	5	0.00
X	M1	301.52	325.79	5	0.00
X	M2	1194.73	1187.49	2005	0.00
X	M3	989.50	999.15	5	0.00
X	Q3A	574.32	564.24	5	0.00
X	Q3B	581.55	625.06	5	0.00
X	M3V	25.63	25.89	2001	25.63
X	M4V	0.00	0.37	1	0.00
X	M4	-347.35	-347.44	2001	-347.35
X	M5	148.22	149.68	2001	148.22
X	Q4A	0.00	3.48	5	0.00
X	Q4B	0.00	3.48	5	0.00
X2	M5S	8.06	9.38	2001	8.06
X2	Q4A	571.38	554.71	5	0.00
X2	Q4B	616.91	619.20	5	0.00
B0	M1	0.00	9.77	1001	0.00
B3	M1	0.00	0.19	1	0.00
X2	Q5A+C	486.11	479.97	1	486.11
X2	Q5B	425.84	427.94	1	425.84
X2	M7	357.27	358.04	1	357.27
B43	M1	702.99	710.94	1	702.99
B43	Q1A+C	1027.50	1033.07	1	1027.50
B42	Q3B	1057.52	1066.93	2001	1057.52

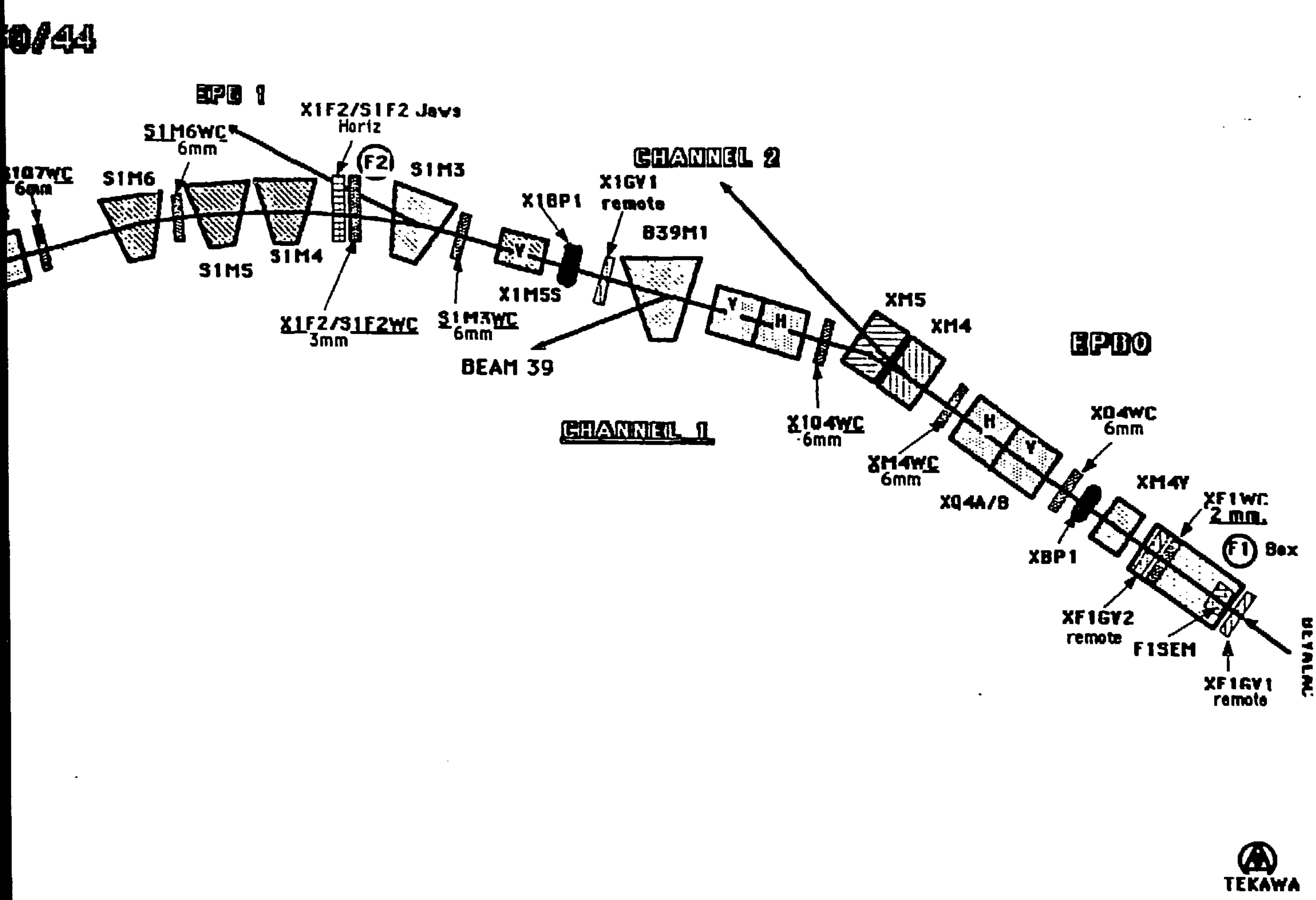
3.6.5 Beam 43 Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	X2F2WC	0.22	0.88	2.0
F3	B43WC1	0.74	0.60	-10.5
F4	Center Plastic Ball (CPB)	0.86	0.74	-1.3

3.7 Beam 44



BEAM 30/44
SEPTUM CHANNEL
S1Q7WC
6mm
S1Q7A/B
S1M6S
Vert
S1F3 Jaws
Horiz-Vert
F3
S1M7
B30GV1
remote
B30BP
B30WC1
6mm
BEAM 30
B30M1S
Vert
B30Q1
B30M2
S1F3WC
2mm
S1M6SWC
6mm
B44GV1
remote
B30Q2
B30Q3A/B
B30Q4A/A
B30M7
B30M6
F4
B44BP
B44Q1A/B
B30WC2
2mm
B30WC3
6mm
F5
B44WC2
6mm
B44SL1
Horiz-Vert
B44WC1
2mm
B30WC5
6mm
B30WC4
2mm
B44Q2A/B
B44M1
BEAM 44
B44WC4
(portable)
2mm
B44WC3
6mm



0/44
EPB 1
X1F2/S1F2 Jaws
Horiz
S1M6WC
6mm
F2
S1M3
CHANNEL 2
S1Q7WC
6mm
S1M6
X1BP1
X1GV1
remote
B39M1
S1M5
S1M4
X1M5S
X1F2/S1F2WC
3mm
S1M3WC
6mm
BEAM 39
XM5
XM4
EPBO
CHANNEL 1
X1Q4WC
6mm
XM4WC
6mm
XQ4A/B
XQ4WC
6mm
XM4Y
XF1WC
2 mm.
F1 Box
XBP1
XF1GV2
remote
F1SEM
XF1GV1
remote
BEVALAC
TEKAWA

XBL 874-1704

a small ring, gives a practical lower limit to the longitudinal impedance that can be achieved.

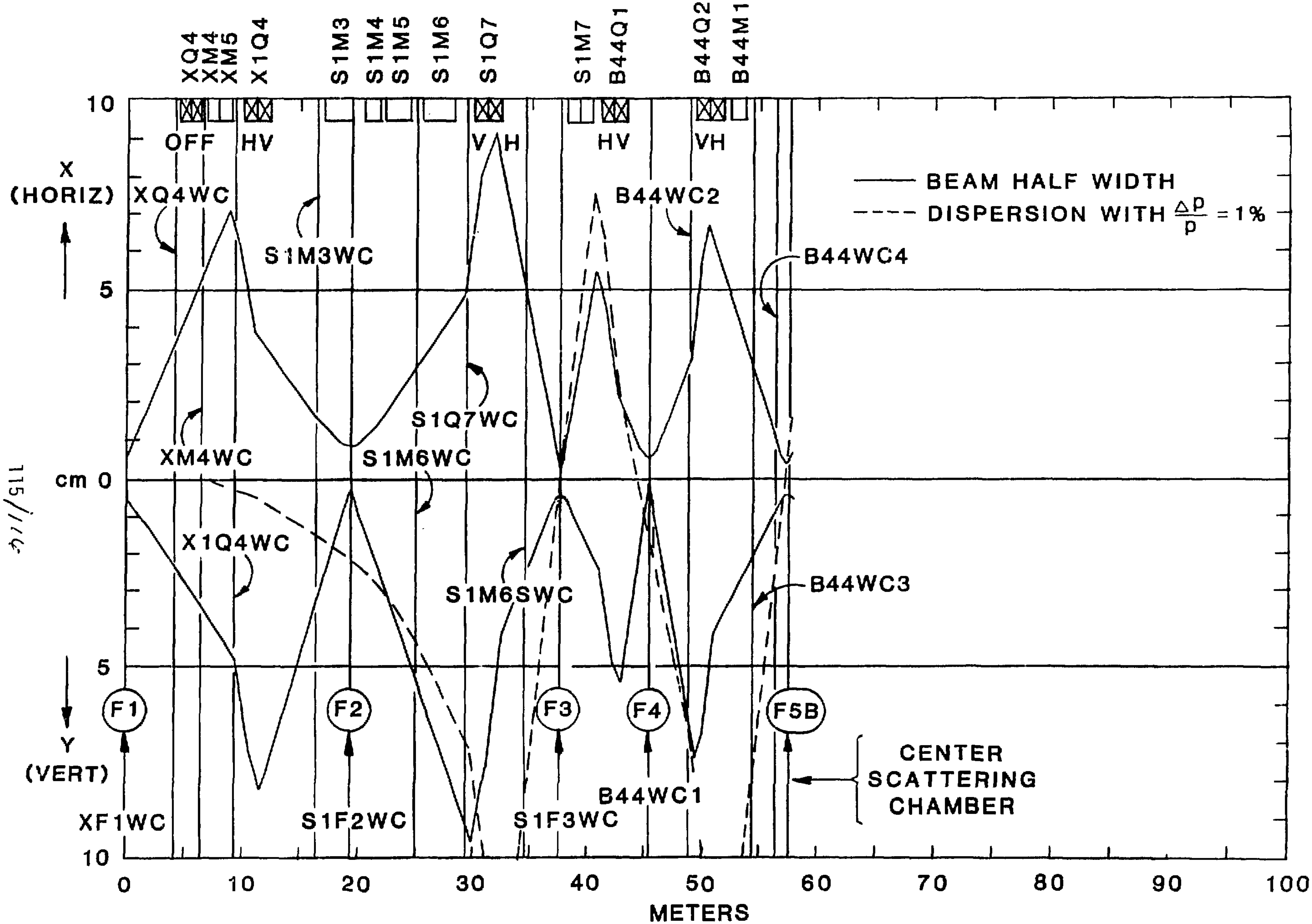
Results of ZAP calculations for the four lattices are summarized in Table II. For the purposes of a damping ring, all of the candidate lattices appear to be suitable. We can see in Table II that, for an rms momentum spread of 1×10^{-3} or less, we are able to achieve a normalized longitudinal emittance of 0.025 m or better at a bunch intensity of at least 1×10^{10} per bunch. We note, however, that the values of $\mathcal{B}_\ell$ that correspond to the Palmer[4] DR criterion are a factor of 5-10 lower than the value of $\mathcal{B}_\ell = 100$ specified by Pellegrini.[3] It is also important to note here that the parameters for Lattice 1 imply a low frequency, high voltage RF system. This clearly would involve practical difficulties in a relatively small ring.

There is an implicit assumption in our calculations that we can actually achieve an emittance coupling of 1% with low emittance lattices such as the ones considered here. Given the very strong focusing required to reach these emittance values, and the precision with which magnets can reasonably be fabricated and aligned, this is not certain. We note, however, that the VUV ring at BNL has reportedly achieved emittance coupling values below 1% (albeit with a higher emittance lattice), so we clearly cannot consider this to be an unreasonable specification at this stage.

If we consider the use of such rings in a high-gain FEL mode, at a wavelength of, say, 40 Å, the results are, unfortunately, less encouraging. In this case, we require small values for both the bunch length (to keep the proper phase relationship in the undulator) and the momentum spread (to avoid substantial gain reduction from Landau damping). The required value for the rms momentum spread for this application is about 5×10^{-4}, which should be achievable. However, the bunch length requirement of $\sigma_\ell \approx 1$ mm is more difficult. In the present cases (at their nominal operating energies), it was not possible to achieve a bunch length as low as 1 mm, even with a rather high frequency (1000 MHz) RF

Beam 44 Magnet Parameters (Cont.)

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG-m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
S1M6	2.250			-6.18	31.07	4.15	4.15	0	4.38x15x84H
---S1Q7WC	2.350								
	0.336								
S1Q7A	1.308	-138	0.1046						8QB48
	0.216								
S1Q7B	1.308	+138	0.1046						8QB48
---S1M6SWC	1.608								
(F3)-S1F3WC	3.700								
	0.700								
S1M7	1.770			-47.37	4.053	25.0	12.0	12.0	7-1/4x63H
	0.808								
B4401A	0.726	+93	0.1571						12QN24
	0.265								
B44Q1B	0.726	-93	0.1571						12QN24
(F4)-B44WC1	2.686								
---B44WC2	3.405								
	0.295								
B44Q2A	0.726	-93	0.1571						12QN24
	0.265								
B44Q2B	0.726	+93	0.1571						12QN24
	0.460								
B44MI	1.036			-32.34	5.938	10.0	5.0	5.0	8x16x36C
---B44WC3	1.094								
(F5A)-B44C1M	3.570								
---B44WC4	1.550								
(F5B)-B44CSC	1.116								



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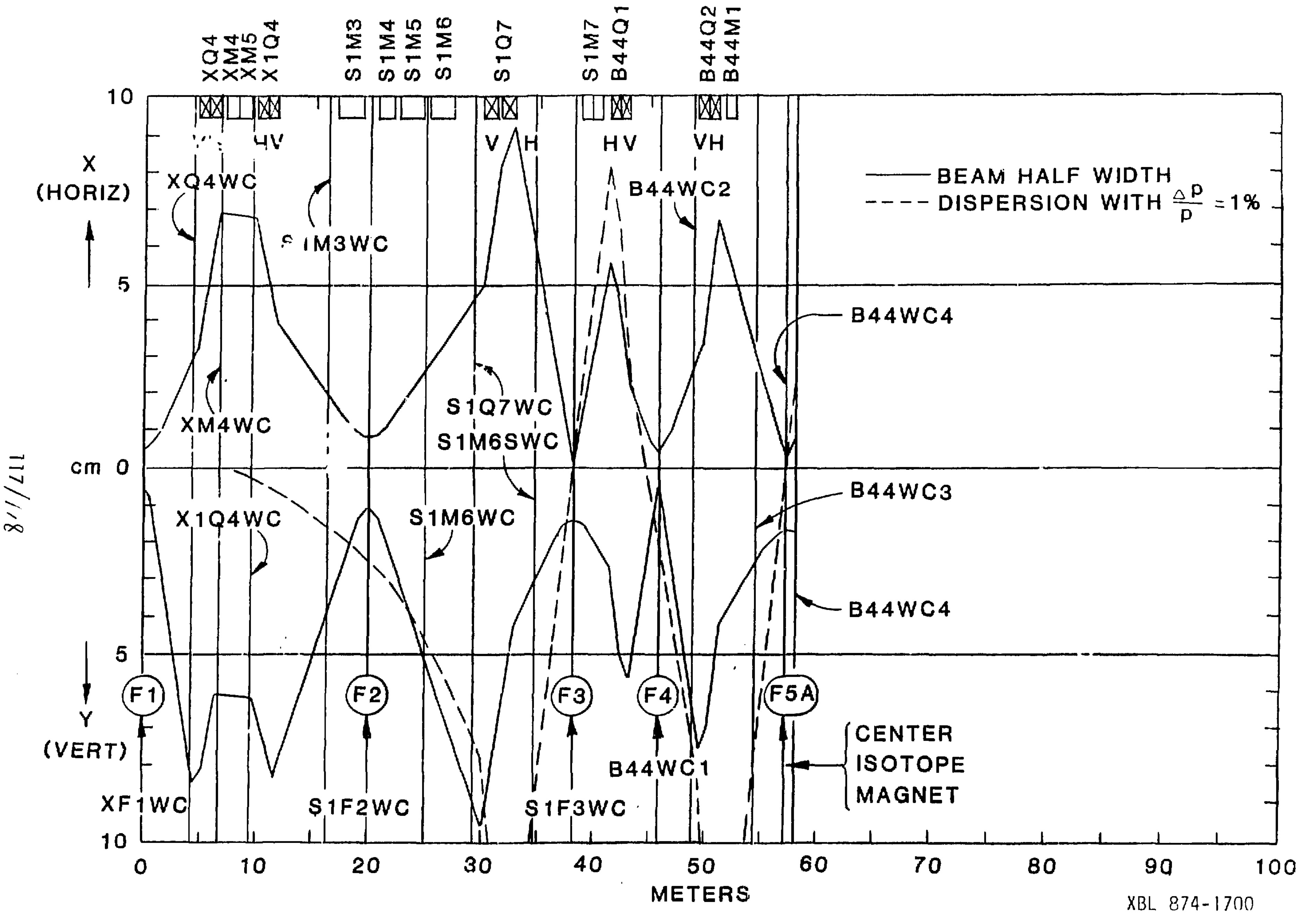
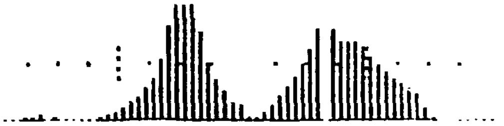
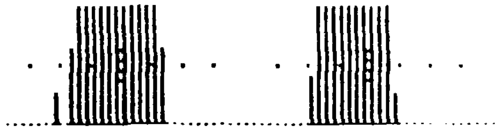
SEC 3.7.3 BEAM 44 (I)



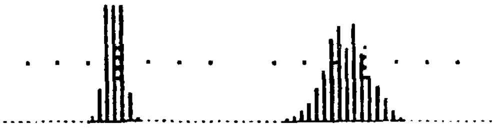
SEC 3.7.3 BEAM 44 (II)



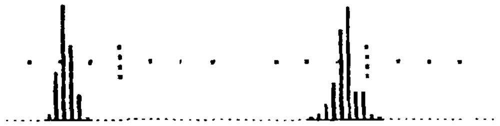
B44WC4 1000 Volts
Manual Range 6 B On
08:42:37 20 Feb 87 2 MM



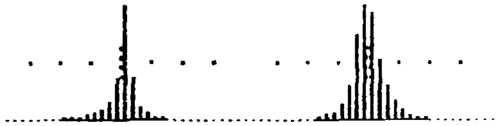
B44WC3 1000 Volts
Manual Range 6 B Off
08:43:40 20 Feb 87 6 MM



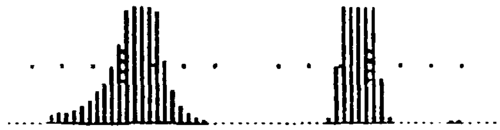
B44WC2 1000 Volts
Manual Range 7 B On
08:44:40 20 Feb 87 6 MM



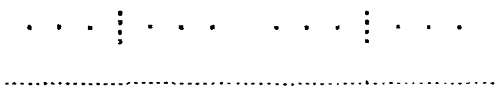
B44WC1 500 Volts
Auto Range 7 B On
08:45:29 20 Feb 87 2 MM



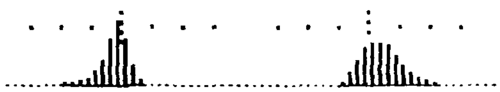
S1F3 500 Volts
Auto Range 7 B On
08:48:21 20 Feb 87 2 MM



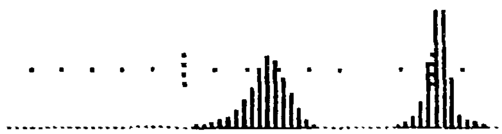
S1M6S 750 Volts
Manual Range 7 B On
08:49:16 20 Feb 87 6 MM



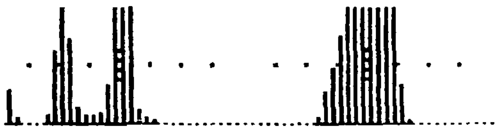
S1M6S 750 Volts
Auto Range 0 B On
08:51:08 20 Feb 87 6 MM



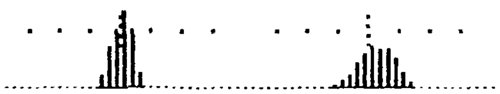
S1M6 750 Volts
Auto Range 7 B On
08:51:43 20 Feb 87 6 MM



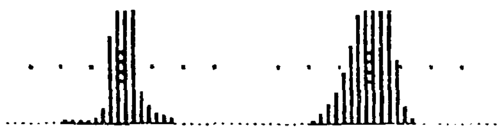
S1/X1F2 750 Volts
Auto Range 7 B On
08:52:18 20 Feb 87 3 MM



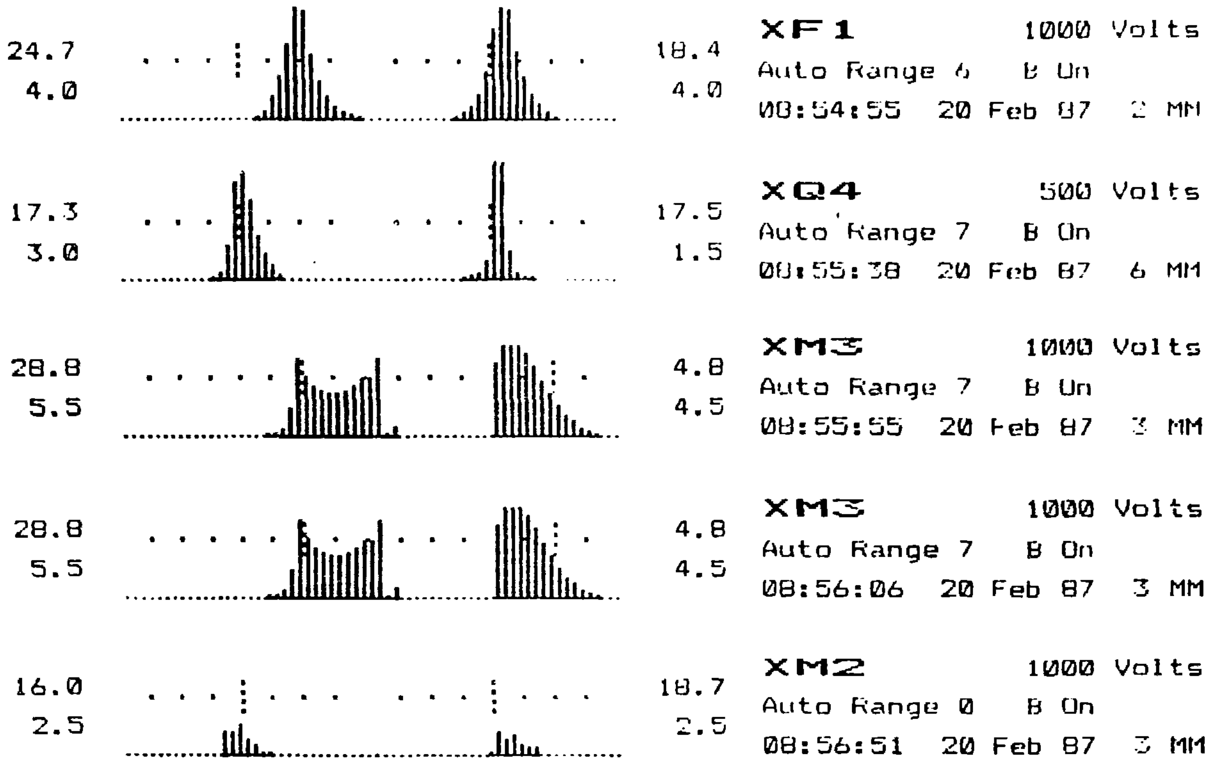
S1M3 500 Volts
Manual Range 5 B On
08:53:05 20 Feb 87 6 MM



X1Q4 1000 Volts
Auto Range 1 B On
08:53:55 20 Feb 87 6 MM



XM4 500 Volts
Auto Range 7 B On
08:54:17 20 Feb 87 6 MM



3.7.4 WIRE CHAMBER PICTURES AND MAGNET CURRENTS OPTICS (I)

$^{139}La^{30+}$

46.83 Mw/A

3030 gauss

[illegible] UNIT DATA

NAME		PLUGS	AMPLITUDE	DELAY	GATE
X	P1	P+	59.[illegible]	400	1490
X	P2	P+	[illegible]2.00	400	1510
X	S2	S	[illegible]05.09	400	1420
X	S1	S	634.47	400	17[illegible]0
X	[illegible]	P	[illegible]14.04	400	1[illegible]0
X	M3	S+	[illegible]11.99	670	1010

NAME		BP	AM	DI	OFFSET
X	P1	0.00	0.56	5	0.00
X	P2	0.00	0.29	5	0.00
X	S1	0.00	0.00	5	0.00
X	S2	0.00	3.18	5	0.00
X	M1	1[illegible]1.16	171.95	5	0.00
	M2	722.84	727.09	5	0.00
X	M3	614.94	604.40	5	0.00
X	Q3A	261.46	236.44	5	0.00
X	Q3B	222.86	235.22	5	0.00
X	M3V	12.96	12.46	2001	12.96
X	M4V	0.00	0.24	2001	0.00
X	M4	241.68	246.21	2001	241.68
X	M5	127.21	129.75	2001	127.21
X1	Q4A	493.73	464.52	2005	0.00
X1	Q4B	480.39	479.99	2005	0.00
X1	M5S	16.53	15.18	2001	16.53
X	Q4A	0.00	3.48	5	0.00
X	Q4B	0.00	4.64	5	0.00
S1	M3	70.88	73.86	2001	70.88
S1	M4	663.01	651.20	2005	0.00
S1	M5	267.37	266.99	2005	0.00
S1	M6	105.22	107.72	2001	105.22
S1	Q7A	352.42	352.53	2005	0.00
S1	Q7B	386.54	377.29	2005	0.00
S1	M6S	6.54	9.21	1	6.54
S1	M7	556.32	566.68	2001	556.32
B44	Q1A	1706.42	1701.46	2001	1706.42
B44	Q1B	1680.57	1658.96	2001	1680.57
B44	Q2A	1333.12	1354.37	2001	1333.12
B44	Q2B	1107.16	1127.70	2001	1107.16
B44	M1	662.34	656.57	2001	662.34

OPTICS (I)

3.7.5 Beam 44 Focal Points (I)

(Standard Optics)

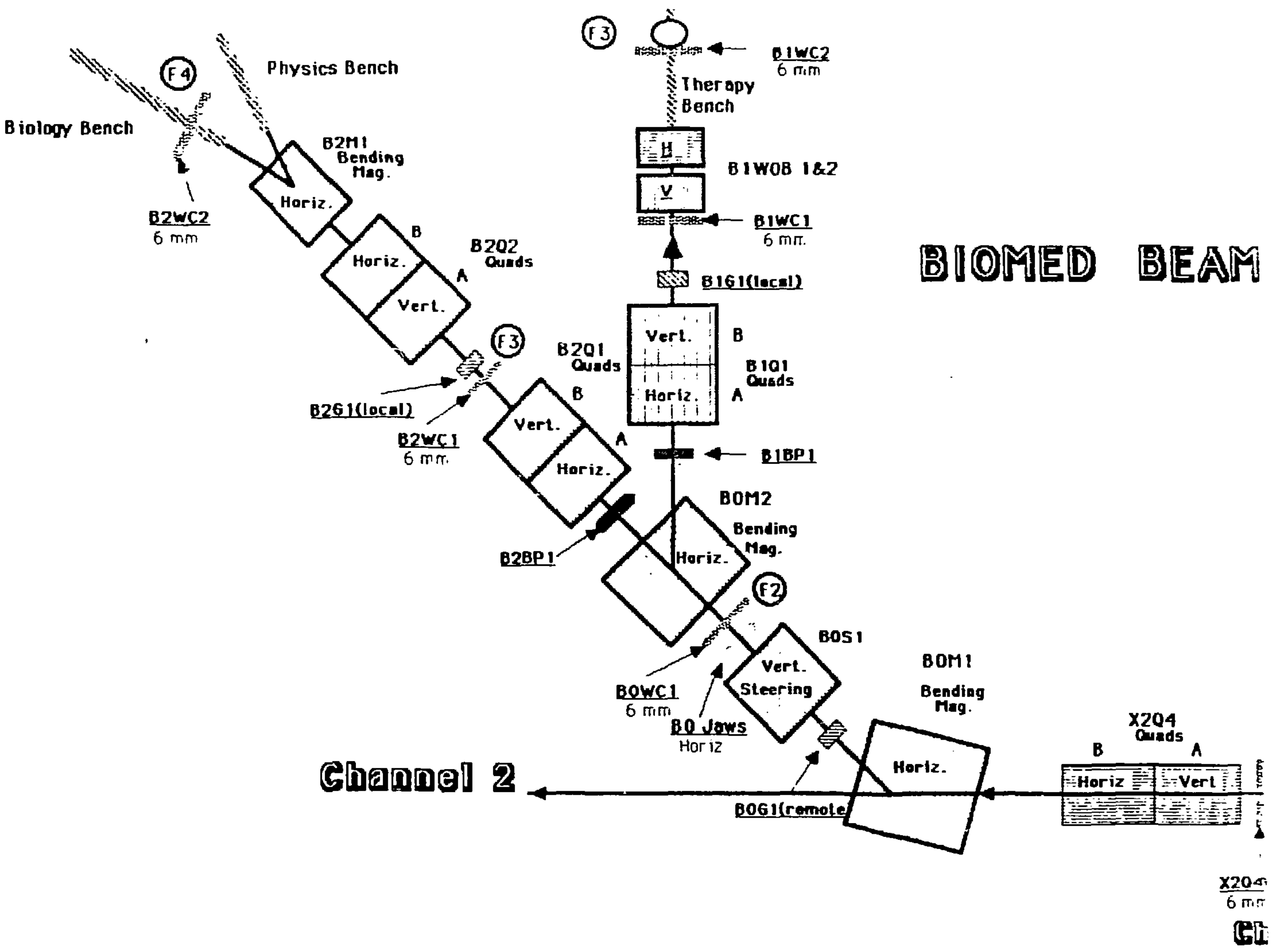
Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	S1F2WC	1.65	0.50	-21.4
F3	S1F3WC	0.44	0.65	1.9
F4	B44WC1	1.00	0.25	-16.7
F5B	Center Scatter Chamber (CSC)	1.04	1.00	2.6

Beam 44 Focal Points (II)

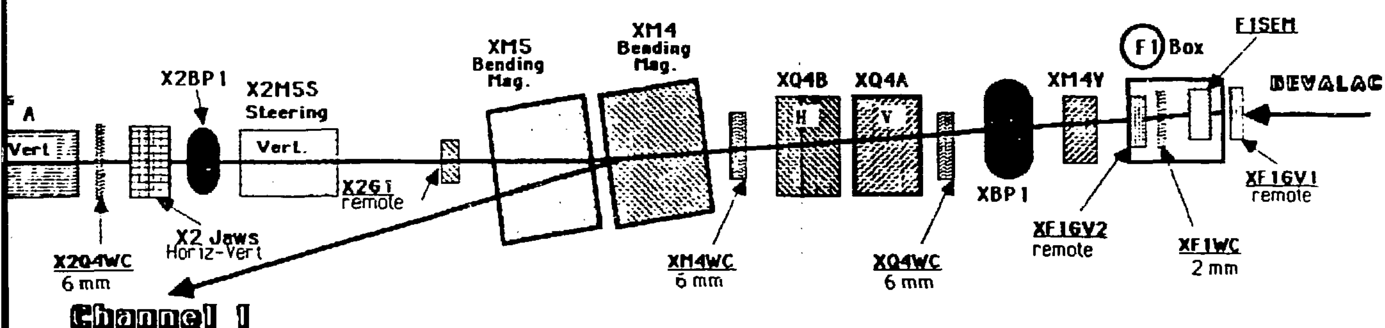
Secondary beam optics

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	S1F2WC	1.64	2.01	-24.5
F3	S1F3WC	0.44	2.67	2.7
F4	B44WC1	1.00	0.98	-18.2
F5A	Center Isotope Magnet (CIM)	0.71	3.12	3.7

3.8 BIOMED I


BIOMED BEAM
Biology Bench
Physics Bench
F4
F3
F2
B2M1
Bending
Mag.
Horiz.
B2WC2
6 mm
B2Q2
Quads
Horiz.
Vert.
B
A
B2G1(local)
B2WC1
6 mm
B2Q1
Quads
Vert.
Horiz.
B2BP1
B1WC2
6 mm
Therapy
Bench
H
V
B1WOB 1&2
B1WC1
6 mm
B1G1(local)
Vert.
Horiz.
B1Q1
Quads
B1BP1
B0M2
Bending
Mag.
Horiz.
B0S1
Vert.
Steering
B0WC1
6 mm
B0 Jaws
Horiz
B0M1
Bending
Mag.
Horiz.
B0G1(remote
Channel 2
X2Q4
Quads
Horiz
Vert
6 mm

EAMLINE



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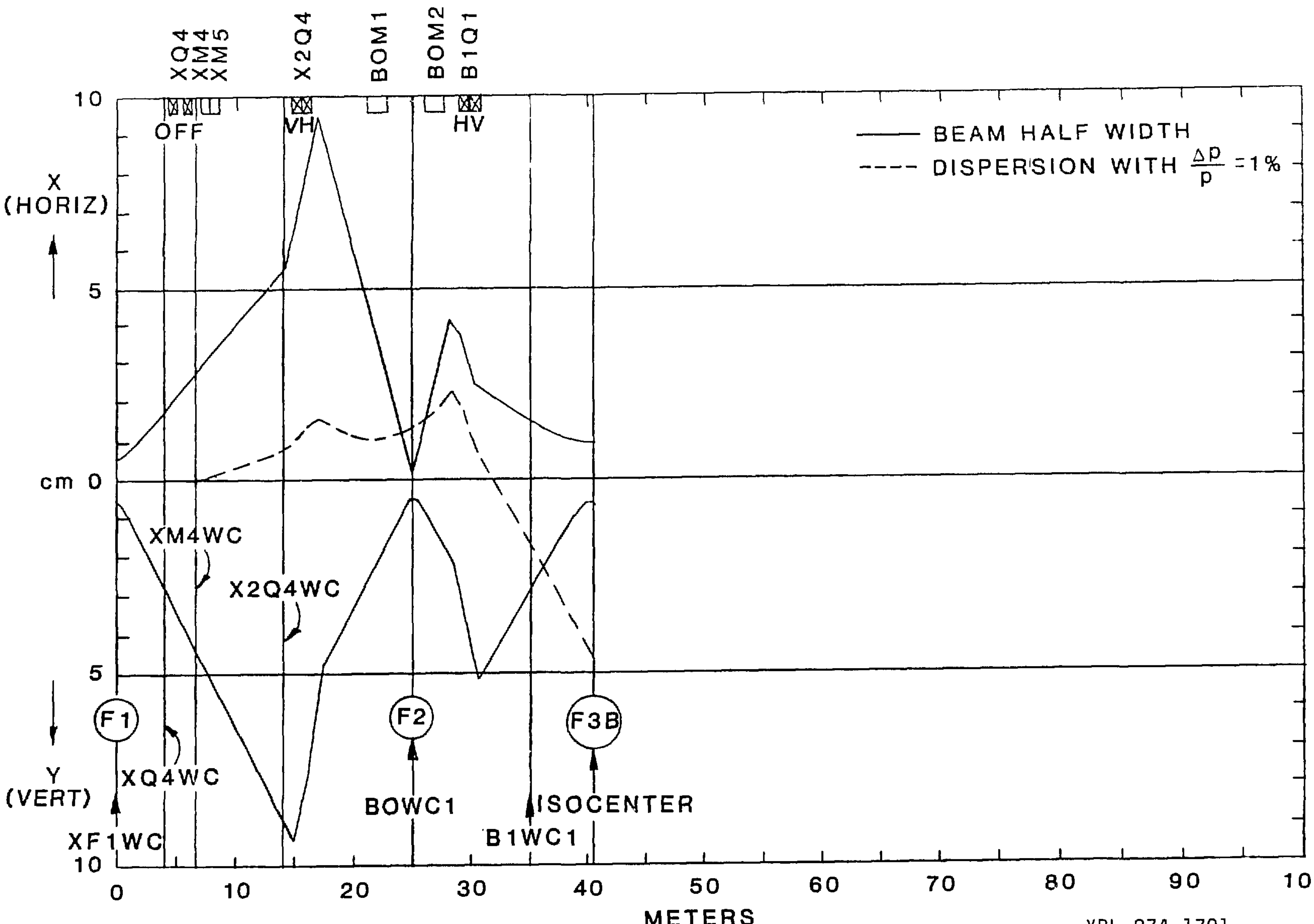
3.8.2 Biomed I Magnet Parameters

Beam Line Element	Effective Length (m)	Quadrupole Magnet Max. Gradient (kG/m)	Quadrupole Magnet Pole tip Radius (m)	Dipole Magnet Field (192 kG-m) (kG)	Dipole Magnet Bend Radius (m)	Dipole Magnet Bend Angle (deg.)	Dipole Magnet Incoming Edge Angle (deg.)	Dipole Magnet Outgoing Edge Angle (deg.)	Magnet Type (in)
(F1)-XF1WC	-								
--- XQ4WC	4.000								
	0.221								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
--- XM4WC	0.220								
	0.242								
XM4	1.036			11.46	16.75	3.545	0	3.545	6-1/8x18x36C
	0.173								
XM5	1.080			9.26	20.72	2.985	-3.545	6.529	6-1/8x29x36H
--- X2Q4WC	5.415								
	0.495								
X2Q4A	1.308	-138	0.1046						8QB48
	0.216								
X2Q4B	1.308	+138	0.1046						8QB48
	3.142								
BOM1	1.898			27.82	6.902	15.75	7.875	7.875	5.4x16x72H
(F2)-BOWC1	2.756								
	0.350								
BOM2	1.898			27.82	6.902	15.75	7.875	7.875	5.4x16x72H
	1.138								
B1Q1A	0.882	+117	0.1016						LP8Q32
	0.160								
B1Q1B	0.882	-117	0.1016						LP8Q32
(F3A)-B1WC1	4.000								
(F3B)-B1ISC	5.704								



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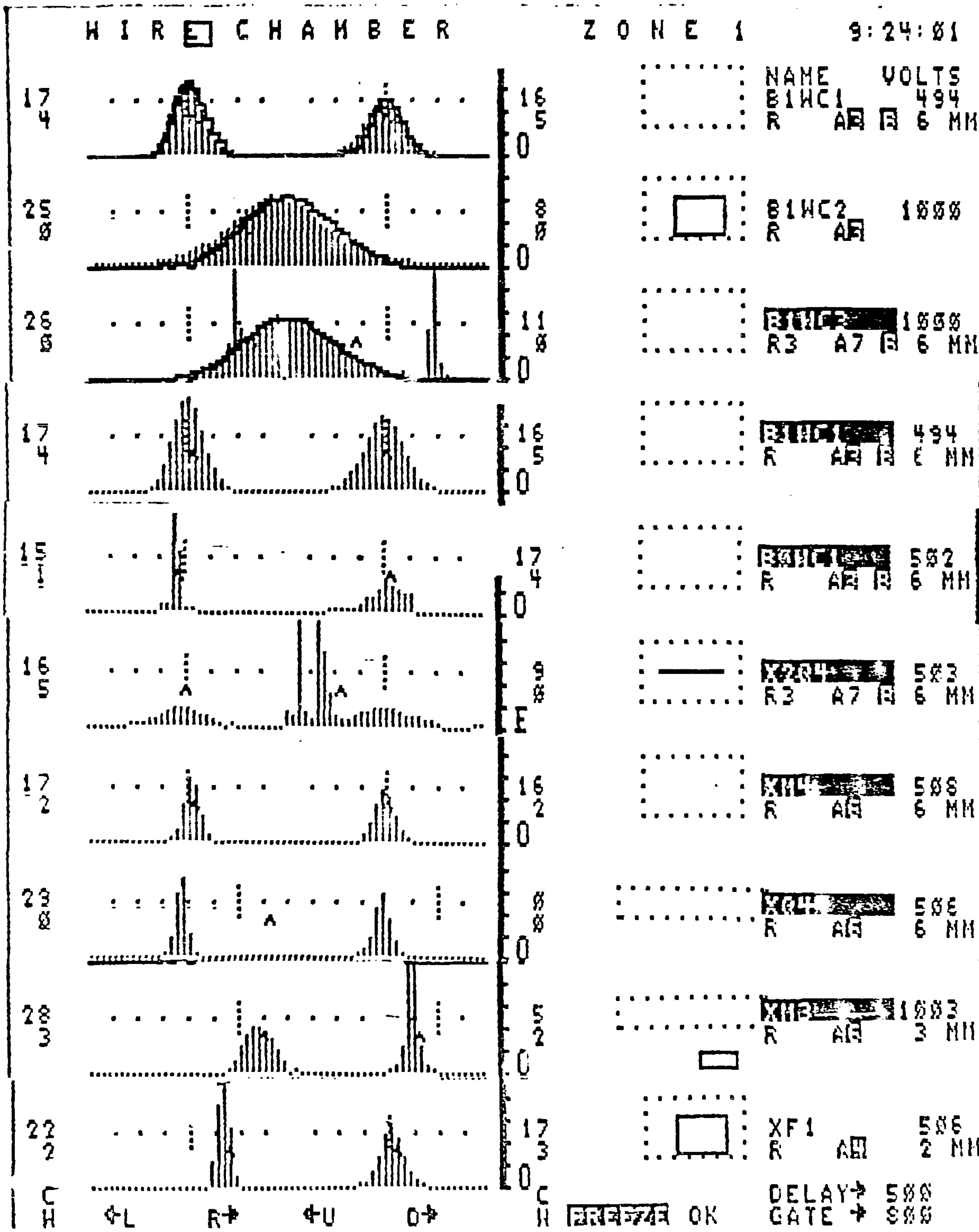
SEC 3.8.3 BIO MED I

131/132



3.8.4 WIRE CHAMBER PICTURES AND CURRENTS

17OCT85 EPB ACL PRINT 9:27:31

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT	17OCT85	9:27:31	Ø	BIOM1

COMMENTS

BIOM1

585MEV NEON TO CAVE 1
E 594.ØØ S 586.5Ø
RAD= 599.5
EXT PFW ACL= 5234 EXT
XS1 FEEDBACK SPILL
BEAM AT WIRE 17 AT F1
LARGE BEAM AT B1WC1 & B1WC2
COMPUTER CONTROLED SPILL
TUNE WITH NEW EPB Ø AREA

B = 5.234 kG

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	8Ø.35	4ØØ	168Ø
X	P2	P+	8.18	4ØØ	151Ø
X	S2	S+	291.31	47Ø	13ØØ
X	S1	S+	125.66	44Ø	115Ø
X	S2	P+	3Ø.84	45Ø	11ØØ
X	M3	S+	-9.77	4ØØ	91Ø
X	S1	P+	15.5Ø	4ØØ	124Ø
X	M2	S+	-17.61	42Ø	112Ø

NAME		SP	AM	DI	OFFSET
X	P1	Ø.ØØ	Ø.88	5	Ø.ØØ
X	P2	Ø.ØØ	Ø.ØØ	5	Ø.ØØ
X	S1	Ø.ØØ	Ø.ØØ	5	Ø.ØØ
X	S2	Ø.ØØ	3.54	5	Ø.ØØ
X	M1	346.42	375.22	5	Ø.ØØ
X	M2	1Ø98.81	11Ø6.99	2ØØ5	Ø.ØØ
X	M3	917.Ø4	92Ø.99	5	Ø.ØØ
X	Q3A	521.84	5Ø9.83	5	Ø.ØØ
X	Q3B	524.3Ø	562.Ø4	5	Ø.ØØ
X	M3V	41.84	41.65	2ØØ1	41.84
X	M4V	Ø.ØØ	Ø.ØØ	1	Ø.ØØ
X	M4	-349.83	-35Ø.17	2ØØ1	-349.83
X	M5	119.59	121.15	2ØØ1	119.59
X	Q4A	Ø.ØØ	3.48	5	Ø.ØØ
X	Q4B	Ø.ØØ	3.48	5	Ø.ØØ
BØ	M2	1Ø852.46	1Ø845.13*	2ØØ1	1Ø852.46
X2	M5S	11.51	11.9Ø	2ØØ1	11.51
X2	Q4A	48Ø.8Ø	463.85	5	Ø.ØØ
X2	Q4B	5Ø1.95	5ØØ.49	5	Ø.ØØ
BØ	M1	1Ø681.18	1Ø727.59*	3ØØ1	1Ø681.18
BØ	S1	1.25	Ø.77	1	1.25
B1	Q1A	547.35	542.44	1	547.35
B1	Q1B	351.91	353.93	1	351.91

*magnetic field in gauss

DATA FOR ENERGY CALCUL-

INJECTION:HILAC LOCAL

PARTICLE: Ne 2S FREQ :

MASS NUM: 20 2S FIELD: -

CHARGE : 10 K.ENERGY:

INFLECTOR H.V: -17.9 D

EXTRACTION: PFW: (ON:) OFF:

FIELD: 5234 P1 CUR

FREQ: 1.970 P2 CUR

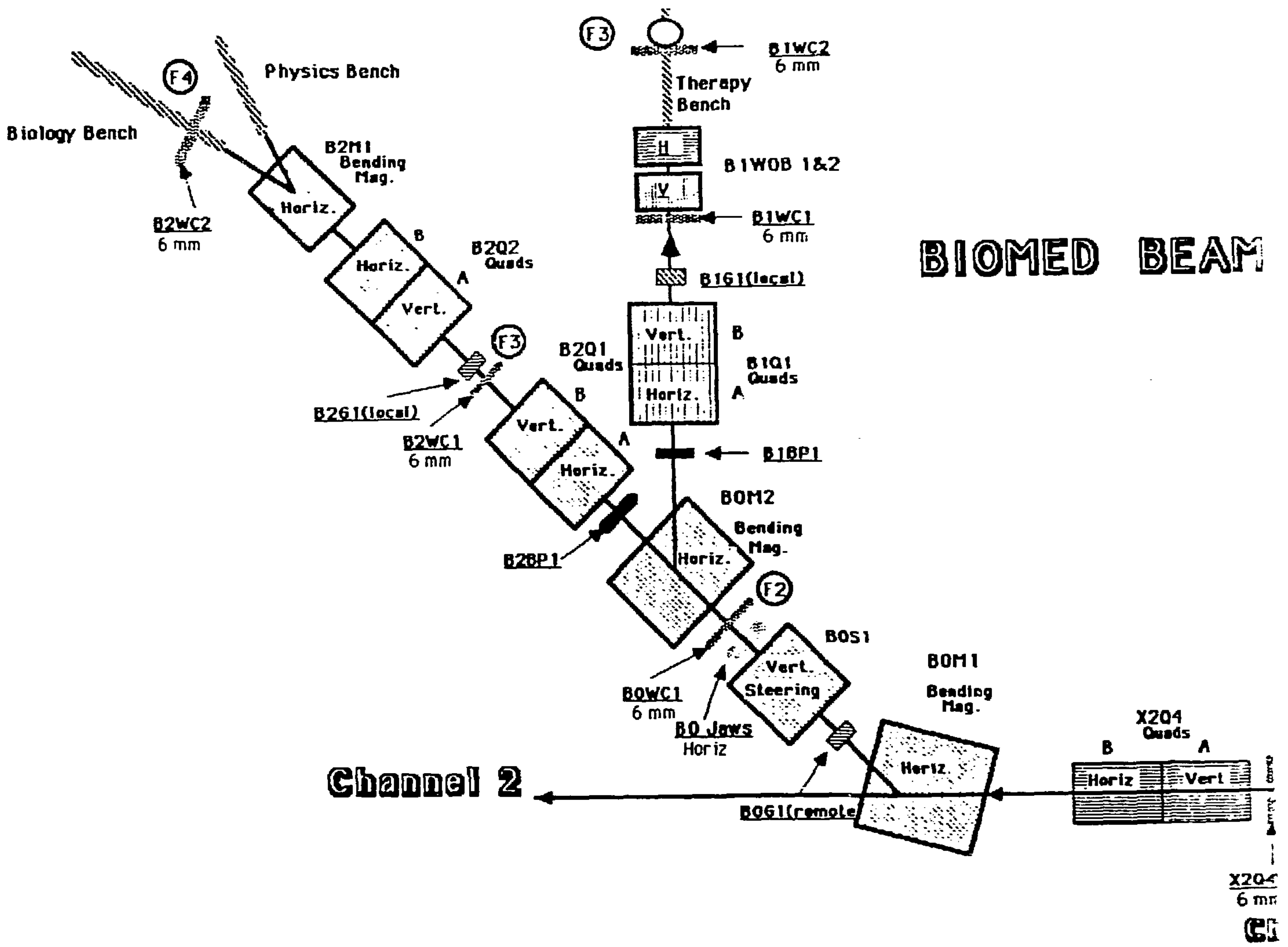
BEAM RAD: 599.5

RADIUS		CURRENT	TAIL
M1: 594	:	375	RISE:
M2: 586.6	:	1107	TIME:
M3: ------	:	921	S1 ON:

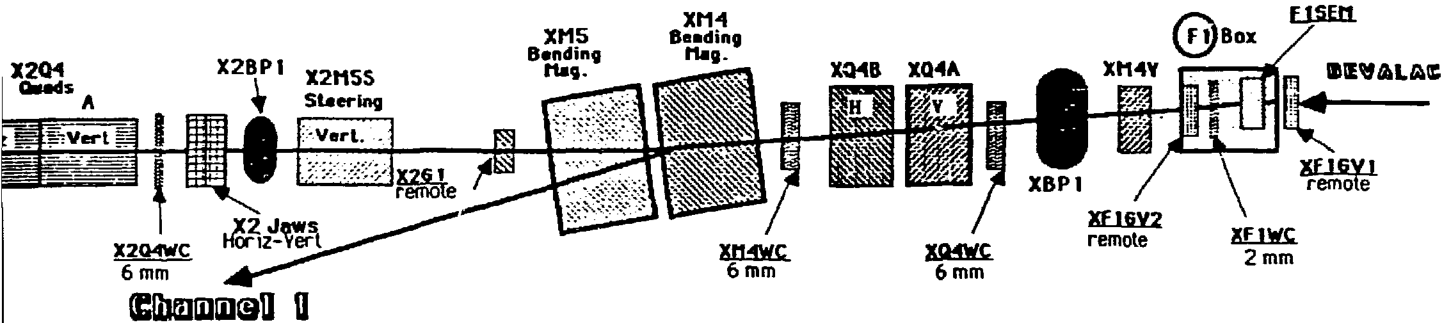
3.8.5 Biomed I Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	B0WC1	0.98	0.98	13.0
F3B	Isocenter (ISO)	1.92	1.21	-45.0

3.9 BIOMED II


BIOMED BEAM
Channel 2
Physics Bench
Biology Bench
Therapy Bench
F4
F3
F2
B1WC2
6 mm
B1WOB 1&2
H
V
B1WC1
6 mm
B1G1(local)
Vert.
Horiz.
B1Q1 Quads
A
B
B1BP1
B2M1 Bending Mag.
Horiz.
B2WC2
6 mm
B2Q2 Quads
B2Q1 Quads
B2G1(local)
B2WC1
6 mm
B2BP1
B0M2 Bending Mag.
B0S1
Vert. Steering
B0WC1
6 mm
B0 Jaws
Horiz
B0M1 Bending Mag.
B0G1(remote)
X2Q4 Quads
Horiz
Vert
6 mm

BEAMLINE



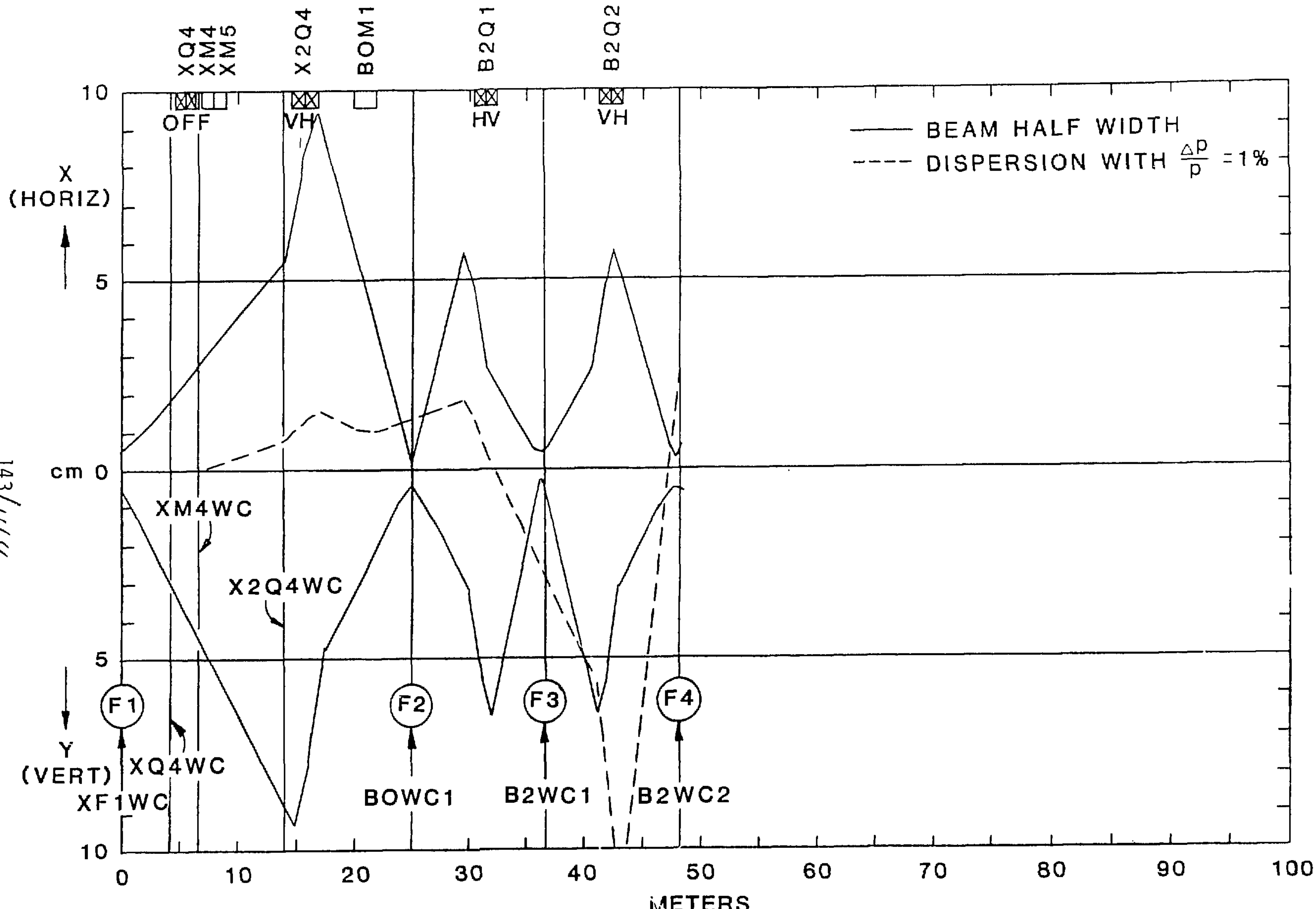
XBL 874-1705

3.9.2 Biomed II Magnet Parameters

Beam Line Element	Effective Length (m)	Quadrupole Magnet		Dipole Magnet					Magnet Type (in)
		Max. Gradient (kG/m)	Pole tip Radius (m)	Field (192 kG·m) (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	
(F1)-XF1WC	-								
--- XQ4WC	4.000								
	0.221								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
--- XM4WC	0.220								
	0.242								
XM4	1.036			11.46	16.75	3.545	0	3.545	6-1/8x18x36C
	0.173								
XM5	1.080			9.26	20.72	2.985	-3.545	6.529	6-1/8x29x36H
--- X2Q4WC	5.415								
	0.495								
X2Q4A	1.308	-138	0.1046						8QB48
	0.216								
X2Q4B	1.308	+138	0.1046						8QB48
	3.142								
BOM1	1.898			27.82	6.902	15.75	7.875	7.875	5.4x16x72H
(F2)-BOWC1	2.756								
	4.651								
B2Q1A	0.882	+117	0.1016						LP8Q32
	0.160								
B2Q1B	0.882	-117	0.1016						LP8Q32
(Fe)-B2WC1	4.578								
	4.581								
B2Q2A	0.882	-117	0.1016						LP8Q32

Biomed II Magnet Parameters (cont.)

Beam Line Element	Effective Length (m)	Quadrupole Magnet Max. Gradient (kG/m)	Quadrupole Magnet Pole tip Radius (m)	Dipole Magnet Field (192 kG-m) (kG)	Dipole Magnet Bend Radius (m)	Dipole Magnet Bend Angle (deg.)	Dipole Magnet Incoming Edge Angle (deg.)	Dipole Magnet Outgoing Edge Angle (deg.)	Magnet Type (in)
	0.160								
B2Q2B	0.882	+117	0.1016						LP8Q32
	0.947								
B2M1	1.085			±37.08	5.178	± 12	0	12	8x18x36LPH
(F4)-B2WC2	3.000								



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SEC 3.9.3 BIO MED II

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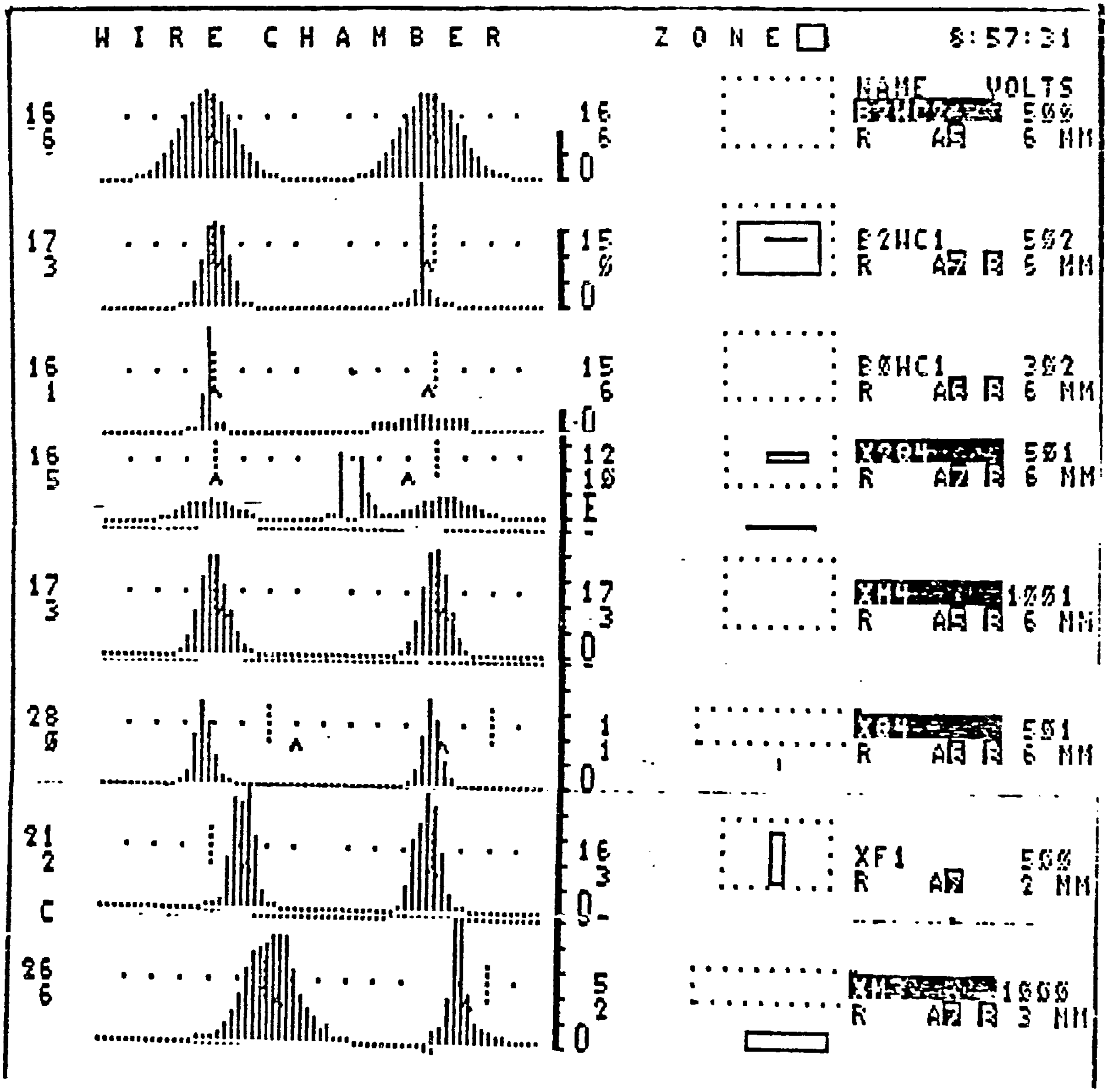


3.9.4 WIRE CHAMBER PICTURES AND CURRENTS

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT B2	15OCT85	9:03:03	0	BIOM2

COMMENTS

NE 5666 B2
670MEV/N NEON TO BIO BENCH
NEW EPB0 TUNE. CTR. AT XM4 WC.
X2M5S ON AND IN CAVE 1 POLARITY
E 594.00 S 586.50
B2M1 IN REVERSE POL. 8/64" PB.
15 GUASS TW. NO EXT PFW.

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	80.76	400	1680
X	P2	P+	39.95	400	1510
X	S2	S+	291.31	470	1300
X	S1	S+	156.49	440	1060
X	S2	P+	30.85	450	1100
X	M3	S+	14.22	400	930

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.88	5	0.00
X	P2	0.00	0.00	5	0.00
X	S1	0.00	0.44	5	0.00
X	S2	0.00	2.69	5	0.00
X	M1	460.58	499.13	5	0.00
X	M2	1259.35	1259.20	2005	0.00
X	M3	965.14	972.44	5	0.00
X	Q3A	621.59	610.59	5	0.00
X	Q3B	670.13	723.25	5	0.00
X	M3V	20.00	20.03	2003	20.00
X	M4V	0.00	0.12	2001	0.00
X	M4	-349.74	-349.49	2001	-349.74
X	M5	148.75	150.07	2001	148.75
X	Q4A	0.00	3.48	5	0.00
X	Q4B	0.00	3.48	5	0.00
B0	M2	0.00	29.31	1	0.00
X2	M5S	34.00	30.60	2003	34.00
X2	Q4A	524.76	507.82	5	0.00
X2	Q4B	555.54	551.78	5	0.00
B0	M1	11592.24	11606.89*	3003	11592.24
B0	S1	85.02	85.41	1	85.02
B2	M1	472.04	472.42	2001	472.04
B2	Q1A	800.00	800.20	1	800.00
B2	Q1B	839.72	839.44	1	839.72
B2	Q2A	735.08	718.64	2001	735.08
B2	Q2B	752.11	752.49	2001	752.11

* magnetic field in gauss

DATA FOR ENERGY CALCULAT

INJECTION:HILAC LOCAL

PARTICLE: Ne 2S FREQ : 2

MASS NUM: 20 2S FIELD: 4

CHARGE : K.ENERGY: 6

INFLECTOR H.V: -17.8 D

EXTRACTION: PFW: ON: OFF:

FIELD: 5666 P1 CUR:

FREQ: 2.027 P2 CUR:

BEAM RAD: 600

	RADIUS	CURRENT	TAIL W
M1:	594	499	RISE: /
M2:	586.5	1259	TIME:
M3:	------	972	S1 ON:

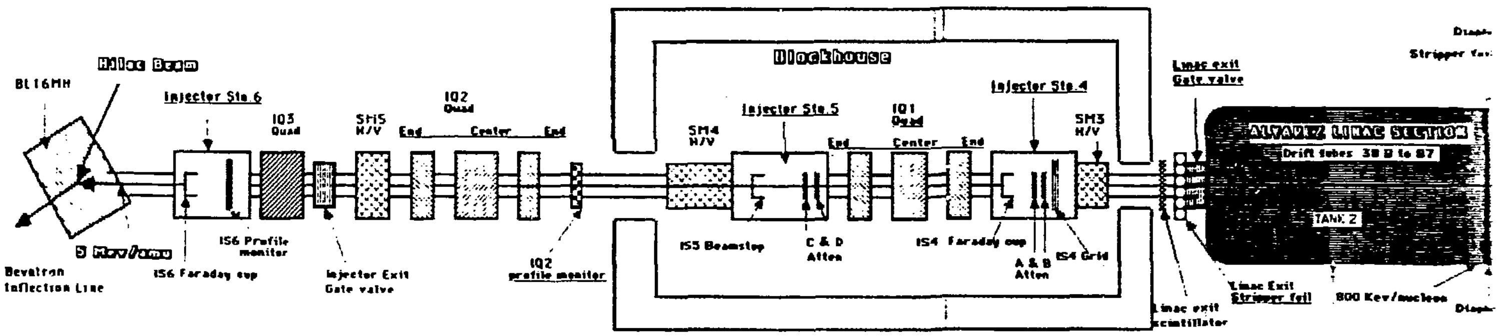
3.9.5 Biomed II Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (mm/%)
F1	XF1WC	1.0	1.0	0.0
F2	B0WC1	0.40	0.98	13.0
F3	B2WC1	0.84	0.45	-26.9
F4	B2WC2	0.43	1.03	13.2

3.10 Local Injector

3.10 SCHEMATIC OF THE LOCAL

5 MEV LOCAL INJECT



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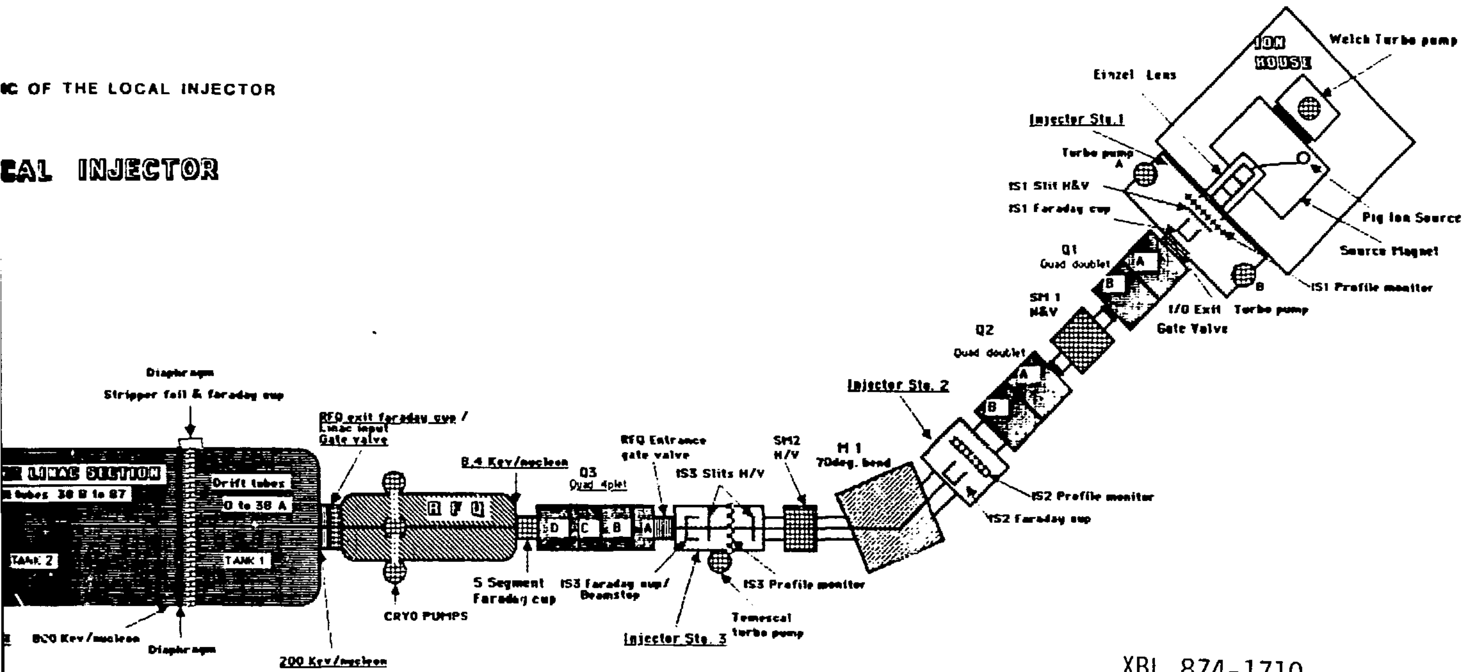
IC OF THE LOCAL INJECTOR

CAL INJECTOR



XBL 874-1710

3.10.2 Local Injector Tuning Parameters

The following tables lists some of the important parameters for tuning the local injector. The first table 'Local Tune' lists the typical tune for the Local injector from the source to exit of Linac for several different ions which are used most often for the Bevatron. The next set of tables are actual tuning parameters saved on the computer for setting up the Local Injector for the different ions. As with EPB current computer readouts, column one is the setpoint and column two is the actual current in a particular magnet or source device. Source parameters are listed first followed by the low energy beam transport (LEBT). Finally, currents for the drift tube quads are listed up to the 'blockhouse' or the exit of the Linac (see Fig. 3.10.1) and are saved on the computer. Drift tubes labeled 0 - 38A are located in Tank #1 of the Linac and drift tubes labeled 38B - GR6 are located in Tank #2 of the Linac. The table called 'Linac Tank Gradient Settings' gives the local linacs tank gradients read from a RF pickup coil.

The following are typical ion intensities from the local injector at various stations along the injector line.

Station 3	600 microamps	20 Ne^{+3}
Diaphragm exit foil	550 microamps	20 Ne^{+7}
Linac exit foil	400 microamps	20 Ne^{+10}
Linac exit cup (Station 4)	350 microamps	20 Ne^{+10}
EOS Cup (entrance to Bevatron	150 microamps	20 Ne^{+10}
Accelerated beam	10^{10} particles/pulse	20 Ne^{+10}

Linac Tank Gradient Settings

ION SOURCE	RFQ	Tank 1	Tank 2	Foils: Diaphragm	Foils: Exit	Linac Exit Cup
$_{20}Ne^{+3}$	7 V	7.8 V	7.6 V	IN	IN	$_{20}Ne^{+10}$
$_{20}Ne^{+4}$	5.2 V	6.2 V	7.6 V	IN	IN	$_{20}Ne^{+10}$
$_{22}Ne^{+4}$	6.2 V	6.4 V	8.3 V	IN	IN	$_{22}Ne^{+10}$
$_{4}He^{+1}$	4.2 V	4.7 V	5.2 V	IN	OUT	$_{4}He^{+2}$
$_{12}C^{+2}$	6.5 V	7.0 V	6.0V	IN	IN	$_{12}C^{+6}$
$_{2}H^{+1}$	2.1 V	3.4 V	6.7 V	OUT	OUT	$_{2}H^{+1}$
$_{28}Si^{+4}$	6.8 V	8.0 V	8.0 V	IN	IN	$_{28}Si^{+14}$

ION	NEON 3+	NEON 4+	NEON 4+	NEON 4+	CARBON 2	CARBON 2	H2 1+	HE 1+	OXYGEN 3	OXYGEN 3	SI 4+
MASS	20	20	22	22	12	12	2	4	16	16	28
T1 CHARGE	3	4	4	4	2	2	1	1	3	3	4
T1 Q/A	0.15	0.2	0.182	0.182	0.167	0.167	0.5	0.25	0.188	0.188	0.143
T2 CHARGE	7	7	7	8	4	5	1	2	5	6	9
T2 Q/A	0.35	0.35	0.318	0.364	0.334	0.417	0.5	0.5	0.313	0.375	0.321
RFQ GRADIENT	7	5.25	5.8	5.8	6.3	6.3	2.1	4.2	5.6	5.6	7.3
T1 GRADIENT	7.8	5.8	6.4	6.4	7	7	2.3	4.7	6.2	6.2	8.2
T2 GRADIENT	7.6	5.7	8.4	7.3	7.9	6.4	5.3	5.3	8.5	7.1	8.3
DIAPHRAM FOIL	IN	IN	IN	IN	IN	IN	OUT	IN	IN	IN	IN
LINAC EXIT FOIL	IN	IN	IN	IN	IN	IN	OUT	OUT	IN	IN	IN
ARC (AMPS)	2.2	2.6	2.6	2.6	2	2	0.8	0.6		2.5	2.5
SARC (VOLTS)	0	0	0	0				0			2500
GAS PULSE (DELAY)	27	11	16				4	5		28	32
GAS PULSE (WIDTH)	5	2	5				4	4		1	1
EXTRACT (KV)	17.5	19.7	19.5	19.5	17	17	18.4	15.3		19.4	19.2
EINZEL (KV)	16.5	16.6	16.8	16.8	15.1	15.1	8.7	10.5		13.6	14.5
MAGNET (AMPS)	235	210	222	222	230	230	135	165		220	250
DECK (KV)	56	43	46	46	51	51	17	34		45	59
LEBT Q1A (AMPS)	3	6.2	9.9	9.9	2.7	2.7	9	18.9		42	180
LEBT Q1B (AMPS)	49	38	41.1	41.1	34.9	34.9	20	34.1		63.9	145
LEBT Q2A (AMPS)	114	92.2	111.3	111.3	101.2	101.2	35	69.4		87.3	123
LEBT Q2B (AMPS)	95	74.5	87.7	87.7	83.5	83.5	30.3	57.5		65.4	88
LEBT M1 (AMPS)	101.4	78.5	84.6	84.6	91.5	91.5	31.05	62.05		82.3	107.7
LEBT Q3A (AMPS)	106.9	60.7	94.9	94.9	112	112	26.1	53		62.4	113.5
LEBT Q3B (AMPS)	182.9	151.1	179.4	179.4	115	115	63.2	122.7		165.7	195
LEBT Q3C (AMPS)	195.2	191.7	189.8	189.8	156	156	71.7	136		194.5	199.6
LEBT Q3D (AMPS)	146.1	136.1	149.2	149.2	124.5	124.5	42.8	93.5		115.6	170.8
LEBT SM1H (AMPS)	0	0	0	0	0	0	0	0			
LEBT SM1V (AMPS)	0	0	0	0	0	0	0	0			
LEBT SM2H (AMPS)	0	0	0	0	0	0	0	0			
LEBT SM2V (AMPS)	0	0	0	0	0	0	0	0			
T1 DRIFT TUBES											
0	33.0	24.7	27.2	27.2	29.6	29.6	9.9	19.8	26.3	26.3	34.6
1	17.0	12.7	14.0	14.0	15.3	15.3	5.1	10.2	13.6	13.6	17.8
2	16.0	12.0	13.2	13.2	14.4	14.4	4.8	9.6	12.8	12.8	16.8
3	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
4	15.0	64.0	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
5	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
6	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
7	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
8	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
9	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
10	18.0	13.5	14.8	14.8	16.2	16.2	5.4	10.8	14.4	14.4	18.9
11	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
12	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0

ION	NEON 3+	NEON 4+	NEON 4+	NEON 4+	CARBON 2	CARBON 2	H2 1+	HE 1+	OXYGEN 3	OXYGEN 3	SI 4+
13	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
14	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
15	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
16	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
17	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
18	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
19	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
20	22.0	16.5	18.1	18.1	19.8	19.8	6.6	13.2	17.6	17.6	23.1
21	23.0	17.3	19.0	19.0	20.7	20.7	6.9	13.8	18.4	18.4	24.1
22	23.0	17.3	19.0	19.0	20.7	20.7	6.9	13.8	18.4	18.4	24.1
23	23.0	17.3	19.0	19.0	20.7	20.7	6.9	13.8	18.4	18.4	24.1
24	23.0	17.3	19.0	19.0	20.7	20.7	6.9	13.8	18.4	18.4	24.1
25	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
26	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
27	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
28	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
29	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
30	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
31	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
32	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
33	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
34	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
35	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
36	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
37	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
HALF QUAD 38A	26.2	19.7	21.6	21.6	23.5	23.5	7.9	15.7	20.9	20.9	27.5
HALF QUAD 38B	21.4	21.4	23.6	20.6	22.4	18.0	15.0	15.0	23.9	20.0	23.3
GRP 4 (25-38)	592.0	592.0	651.6	569.2	620.4	496.9	414.4	414.4	662.0	552.5	645.5
25	592.0	592.0	651.6	569.2	620.4	496.9	414.4	414.4	662.0	552.5	645.5
26	599.0	599.0	659.3	576.0	627.7	502.8	419.3	419.3	669.8	559.1	653.1
27	605.0	605.0	665.9	581.7	634.0	507.8	423.5	423.5	676.5	564.7	659.7
28	612.0	612.0	673.6	589.5	641.3	513.7	428.4	428.4	684.3	571.2	667.3
29	619.0	619.0	681.3	595.2	648.7	519.5	433.3	433.3	692.2	577.7	674.9
30	626.0	626.0	689.0	601.9	656.0	525.4	438.2	438.2	700.0	584.3	682.6
31	633.0	633.0	696.7	608.7	663.3	531.3	443.1	443.1	707.8	590.8	690.2
32	639.0	639.0	703.3	614.4	669.6	536.3	447.3	447.3	714.5	596.4	696.7
33	646.0	646.0	711.0	621.2	676.9	542.2	452.2	452.2	722.4	602.9	704.4
34	653.0	653.0	718.7	627.9	684.3	548.1	457.1	457.1	730.2	609.5	712.0
35	660.0	660.0	726.4	634.6	691.6	554.0	462.0	462.0	738.0	616.0	719.6
36	667.0	667.0	734.1	641.3	699.0	559.8	466.9	466.9	745.8	622.5	727.3
37	674.0	674.0	741.8	648.1	706.3	565.7	471.8	471.8	753.7	629.1	734.9
38	680.0	680.0	748.4	653.8	712.6	570.7	476.0	476.0	760.4	634.7	741.4
GRP 5A (39-50)	680.0	680.0	748.4	653.8	712.6	570.7	476.0	476.0	760.4	634.7	741.4
GRP 5B (51-62)	~~680.0~~	~~680.0~~	~~748.4~~	~~653.8~~	~~712.6~~	~~570.7~~	~~476.0~~	~~476.0~~	~~760.4~~	~~634.7~~	~~741.4~~
GRP 6 (63-74)	490.0	490.0	539.3	471.2	513.5	411.3	343.0	343.0	547.9	457.3	534.3
HALF QUAD 75	490.0	490.0	539.3	471.2	513.5	411.3	343.0	343.0	547.9	457.3	534.3

SAVE1 Ø7:42 Ø5/21/86   22 NEON 4+

STATIONS

ARC I	Ø.ØØØ	Ø.ØØØ	U
ARC E LIM	Ø.ØØØ	Ø.ØØØ	O
SPUT ARC E	Ø.ØØØ	Ø.ØØØ	O
SPUT ARC E L	Ø.ØØØ	Ø.ØØØ	C
EXTRACT E	19.578	Ø.359	O
EINZEL E	16.475	Ø.Ø39	O
MAGNET I	222.8Ø2	Ø.672	O
DECK E	47.ØØØ	Ø.ØØØ	C
LEBT Q1A	Ø.122	1.563	O
LEBT Q1B	39.335	39.463	O
LEBT Q2A	1Ø3.791	1Ø4.127	O
LEBT Q2B	76.88Ø	76.777	C
LEBT M1	84.829	84.786	O
DECK E	47.ØØØ	Ø.ØØØ	C
LEBT Q3A	82.68Ø	84.1Ø3	O
LEBT Q3B	164.7Ø1	166.935	O
LEBT Q3C	195.354	197.411	O
LEBT Q3D	143.773	155.Ø18	C
LEBT SM1H	Ø.ØØØ	Ø.ØØ1	O
LEBT SM1V	Ø.ØØØ	-Ø.ØØ2	O
LEBT SM2H	Ø.ØØØ	Ø.ØØ3	O
LEBT SM2V	Ø.3ØØ	Ø.ØØ5	O

DRIFT TUBES

Ø	3Ø.ØØØ	3Ø.37	O	15	19.ØØØ	19.Ø1	O	3Ø	22.192	22.33	O
1	18.ØØØ	17.9Ø	O	16	19.ØØØ	18.99	O	31	24.832	24.Ø5	O
2	15.369	15.26	O	17	19.ØØØ	18.96	O	32	24.3Ø1	24.93	O
3	16.217	16.Ø6	O	18	19.ØØØ	19.Ø2	O	33	24.417	24.92	U
4	15.997	15.87	O	19	19.ØØØ	19.21	O	34	24.965	24.4Ø	O
5	15.997	15.82	O	2Ø	23.ØØØ	23.Ø4	O	35	24.Ø82	24.31	O
6	17.ØØØ	17.78	O	21	23.ØØØ	22.98	O	36	24.237	23.82	O
7	17.ØØØ	17.Ø5	O	22	23.ØØØ	23.15	O	37	25.796	26.28	O
8	17.ØØØ	17.41	O	23	23.ØØØ	23.Ø8	O	38A	27.355	27.41	O
9	19.ØØØ	18.88	O	24	23.ØØØ	23.Ø7	O	38B	2Ø.ØØØ	19.82	O
1Ø	19.ØØØ	16.27	O	25	23.ØØØ	23.Ø6	O	GR4	64Ø.ØØØ	635.17	O
11	19.ØØØ	18.96	O	26	23.ØØØ	23.Ø7	O	GR5A	66Ø.ØØØ	642.15	O
12	19.ØØØ	18.78	O	27	23.ØØØ	23.12	O	GR5B	683.492	671.45	O
13	19.ØØØ	19.15	O	28	23.ØØØ	23.Ø8	O	GR6	42Ø.ØØØ	411.82	O
14	19.ØØØ	18.79	O	29	24.262	24.27	O				

TIMING

23   3   2Ø 1ØØØ   2Ø 1ØØØ   2ØØ 1ØØØ   6ØØ   4ØØ   2

SAVE2 07:57 03/04/87 CARBON 2+

STATIONS

ARC I	2.198	2.083	O
ARC E LIM	0.000	0.000	O
SPUT ARC E	0.000	0.000	O
SPUT ARC E L	0.000	0.000	C
EXTRACT E	17.552	18.291	O
EINZEL E	17.542	18.217	O
MAGNET I	229.999	230.464	O
DECK E	51.000	51.016	C
LEBT Q1A	2.601	3.028	O
LEBT Q1B	33.663	33.797	O
LEBT Q2A	102.802	103.346	O
LEBT Q2B	87.216	86.935	C
LEBT M1	92.198	92.015	O
DECK E	51.000	50.952	C
LEBT Q3A	87.411	88.889	O
LEBT Q3B	168.578	170.843	O
LEBT Q3C	197.808	199.365	O
LEBT Q3D	156.099	170.256	C
LEBT SM1H	0.000	0.003	O
LEBT SM1V	0.000	-0.001	O
LEBT SM2H	0.000	0.005	O
LEBT SM2V	0.000	0.005	C

DRIFT TUBES

0	32.103	32.23	O	15	20.000	20.02	O	30	23.000	23.16	O
1	18.879	18.70	O	16	20.000	20.04	O	31	23.000	22.26	O
2	18.505	18.42	O	17	20.000	19.98	O	32	23.000	23.57	O
3	16.403	16.21	O	18	20.000	20.07	O	33	23.000	23.46	O
4	15.994	15.81	O	19	20.000	20.25	O	34	23.000	22.52	O
5	15.994	15.68	O	20	23.000	23.09	O	35	23.000	23.24	O
6	15.994	16.64	O	21	23.000	22.97	O	36	23.000	22.62	O
7	15.994	16.38	O	22	23.000	23.13	O	37	23.000	23.05	C
8	15.994	16.24	O	23	23.000	23.04	O	38A	33.005	32.59	C
9	15.994	15.74	O	24	23.000	23.05	O	38B	22.501	22.13	O
10	20.000	19.74	O	25	23.000	23.08	O	GR4	460.000	455.17	O
11	20.000	19.88	O	26	23.000	23.04	O	GR5A	460.635	461.44	U
12	20.000	19.65	O	27	23.000	23.11	O	GR5B	316.874	316.68	O
13	20.000	20.05	O	28	23.000	23.13	O	GR6	448.767	436.24	U
14	20.000	19.84	O	29	23.000	22.93	O				

TIMING

22 4 40 1000 80 1000 120 1000 600 400 2

SAVE3 14:Ø8 12/Ø3/85 HYDROGEN (H2 1+)

STATIONS

ARC I	Ø.826	Ø.652	O
ARC E LIM	2.137	Ø.ØØØ	O
SPUT ARC E	3.Ø53	Ø.ØØØ	O
SPUT ARC E L	Ø.ØØØ	Ø.ØØØ	C
EXTRACT E	18.356	19.1Ø3	O
EINZEL E	8.74Ø	9.143	O
MAGNET I	134.997	134.86Ø	O
DECK E	17.ØØØ	17.333	O
LEBT Q1A	8.999	8.987	O
LEBT Q1B	2Ø.ØØØ	19.634	O
LEBT Q2A	35.ØØØ	34.286	O
LEBT Q2B	3Ø.293	3Ø.379	C
LEBT M1	31.Ø5Ø	3Ø.867	O
DECK E	17.ØØØ	17.3Ø2	O
LEBT Q3A	26.1Ø5	26.569	O
LEBT Q3B	63.211	63.98Ø	O
LEBT Q3C	71.752	71.893	O
LEBT Q3D	42.796	42.686	C
LEBT SM1H	Ø.ØØØ	Ø.ØØ2	O
LEBT SM1V	Ø.ØØØ	-Ø.ØØ2	O
LEBT SM2H	Ø.Ø83	Ø.ØØ4	O
LEBT SM2V	Ø.1Ø2	Ø.ØØ3	O

DRIFT TUBES

Ø	12.Ø67	12.Ø5	O	15	9.459	9.25	O	3Ø	1Ø.351	1Ø.19	O
1	8.1Ø8	7.68	O	16	9.532	9.32	O	31	1Ø.246	9.59	O
2	8.976	8.65	O	17	9.283	9.Ø6	O	32	1Ø.264	1Ø.28	O
3	8.778	8.36	O	18	11.5Ø4	11.31	O	33	1Ø.268	1Ø.18	O
4	8.669	8.32	O	19	11.2Ø9	11.14	O	34	11.5Ø5	11.Ø4	O
5	8.Ø94	7.71	O	2Ø	1Ø.996	1Ø.82	O	35	1Ø.362	1Ø.25	O
6	8.Ø76	8.17	O	21	11.331	11.Ø9	O	36	1Ø.2Ø5	9.76	O
7	7.569	7.34	O	22	11.227	11.1Ø	O	37	1Ø.824	1Ø.85	C
8	8.653	8.54	O	23	11.246	11.Ø7	O	38A	1Ø.863	1Ø.85	C
9	9.768	9.5Ø	O	24	11.Ø74	1Ø.84	O	38B	9.658	9.34	O
1Ø	8.623	7.95	O	25	11.153	1Ø.98	O	GR4	538.633	527.67	O
11	9.137	8.88	O	26	11.256	11.Ø7	O	GR5A	618.999	594.48	O
12	9.Ø26	8.69	O	27	11.199	11.Ø2	O	GR5B	5Ø3.614	489.78	O
13	9.572	9.43	O	28	11.458	11.26	O	GR6	373.895	362.Ø4	O
14	8.817	8.3Ø	O	29	11.453	11.31	O				

TIMING

4 4 2Ø 1ØØØ 8Ø 1ØØØ 12Ø 8ØØ 4ØØ 4ØØ 2

SAVE4 15:09 02/02/87 HELIUM 1+

STATIONS

ARC I	1.200	1.060	O
ARC E LIM	0.000	0.000	O
SPUT ARC E	0.000	0.000	O
SPUT ARC E L	0.000	0.000	C
EXTRACT E	15.139	15.795	O
EINZEL E	13.269	13.802	O
MAGNET I	164.995	165.446	O
DECK E	34.268	34.254	C
LEBT Q1A	18.895	19.243	O
LEBT Q1B	34.170	34.286	O
LEBT Q2A	69.438	69.451	O
LEBT Q2B	57.460	57.436	C
LEBT M1	62.051	61.929	O
DECK E	34.268	34.190	C
LEBT Q3A	53.004	54.115	O
LEBT Q3B	122.698	124.737	O
LEBT Q3C	136.001	136.459	O
LEBT Q3D	93.584	93.578	C
LEBT SM1H	0.000	0.001	O
LEBT SM1V	0.000	-0.002	O
LEBT SM2H	0.000	0.005	O
LEBT SM2V	0.000	0.003	C

DRIFT TUBES

0	22.794	22.98	O	15	15.692	15.65	O	30	18.000	18.13	O
1	12.836	12.49	O	16	15.692	15.69	O	31	18.000	17.36	O
2	13.708	13.49	O	17	15.692	15.63	O	32	18.000	18.39	O
3	14.517	14.27	O	18	15.692	15.68	O	33	18.000	18.28	O
4	13.471	13.22	O	19	15.692	15.79	O	34	18.000	17.59	O
5	13.444	13.10	O	20	19.660	19.71	O	35	18.000	18.18	O
6	12.982	13.42	O	21	19.013	18.96	O	36	20.000	19.66	O
7	12.188	12.39	O	22	19.059	19.16	O	37	20.000	19.99	C
8	12.595	12.69	O	23	18.942	18.94	O	38A	21.612	21.62	C
9	15.885	15.65	O	24	18.000	17.99	O	38B	21.738	21.42	O
10	15.660	15.26	O	25	18.000	18.02	O	GR4	432.332	427.64	O
11	15.954	15.76	O	26	18.000	18.03	O	GR5A	512.796	508.72	O
12	17.215	16.88	O	27	18.000	18.06	O	GR5B	374.994	368.45	O
13	15.692	15.69	O	28	18.000	18.06	O	GR6	356.703	349.09	O
14	14.994	14.71	O	29	18.000	17.93	O				

TIMING

4 2 20 1000 80 1000 120 1000 600 400 2

SAVE5 15:14 11/07/86 OXYGEN 31

STATIONS

ARC I	[illegible].2ØØ	2.1[illegible]	O
ARC E LIM	Ø.ØØØ	Ø.ØØØ	O
SPUT ARC I	Ø ØØØ	Ø.ØØØ	O
SPUT ARC E L	Ø.ØØØ	Ø.ØØØ	C
EXTRACT E	17.7ØØ	18.41Ø	O
EINZEL E	17.ØØØ	17.592	O
MAGNET I	2Ø7.173	2Ø8.181	O
DECK E	45.ØØØ	44.984	C
LEBT Q1A	42.Ø27	41.9Ø5	O
LEBT Q1B	63.895	64.Ø78	O
LEBT Q2A	87.344	87.521	O
LEBT Q2B	65.4Ø3	65.446	C
LEBT MI	82.3Ø2	82.344	O
DECK E	45.ØØØ	45.Ø16	C
LEBT Q3A	62.393	63.ØØ4	O
LEBT Q3B	165.678	167.717	O
LEBT Q3C	194.475	196.63Ø	O
LEBT Q3D	115.513	118.Ø95	C
LEBT SM1H	Ø.ØØØ	Ø.ØØ3	O
LEBT SM1V	Ø.ØØØ	Ø.ØØØ	O
LEBT SM2H	Ø.ØØØ	Ø.ØØ6	O
LEBT SM2V	Ø.ØØØ	Ø.ØØ5	C

DRIFT TUBES

Ø	29.699	29.89	O	15	19.ØØØ	18.98	O	3Ø	23.ØØØ	23.11	O
1	17.5ØØ	17.32	O	16	19.ØØØ	18.97	O	31	2Ø.8ØØ	2Ø.Ø8	O
2	15.999	15.85	O	17	19.ØØØ	18.94	O	32	19.ØØØ	19.44	O
3	15.119	14.89	O	18	19.ØØØ	19.Ø2	O	33	19.ØØØ	19.34	O
4	15.Ø99	14.9Ø	O	19	19.ØØØ	19.2Ø	O	34	19.8ØØ	19.35	O
5	14.999	14.77	O	2Ø	23.4ØØ	23.45	O	35	19.8ØØ	19.9Ø	O
6	14.999	15.6Ø	O	21	23.4ØØ	23.36	O	36	18.4ØØ	18.Ø2	O
7	14.999	15.33	O	22	23.4ØØ	23.51	O	37	17.5ØØ	17.74	O
8	14.999	15.25	O	23	23.4ØØ	23.42	O	38A	26.8ØØ	26.75	O
9	19.ØØØ	18.82	O	24	23.4ØØ	23.42	O	38B	26.ØØØ	25.59	O
1Ø	19.ØØØ	18.7Ø	O	25	23.4ØØ	23.38	O	GR4	6ØØ.ØØØ	595.[illegible]	O
11	19.ØØØ	18.91	O	26	23.4ØØ	23.41	O	GR5A	625.ØØ6	62[illegible].26	O
12	19.ØØØ	18.69	O	27	23.4ØØ	23.46	O	GR5B	425.ØØ6	416.[illegible]2	O
13	19.ØØØ	19.Ø5	O	28	23.ØØØ	23.Ø7	O	GR6	532.576	52[illegible].96	O
14	19.ØØØ	18.82	O	29	23.ØØØ	22.96	O				

TIMING

22 4 2Ø 1ØØØ 8Ø 1ØØØ 13Ø 1ØØØ 6ØØ 4ØØ 2

SAVE6 12:20 09/09/85 linac exit 170 u a alplhas

STATIONS

ARC I	2.000	0.000	O
ARC E LIM	0.000	0.000	O
SPUT ARC E	0.000	0.000	O
SPUT ARC E L	0.000	0.000	O
EXTRACT E	18.049	0.000	O
EINZEL E	9.010	0.000	O
MAGNET I	129.999	0.000	O
DECK E	17.083	0.000	O
LEBT Q1A	3.046	0.000	O
LEBT Q1B	12.576	0.000	O
LEBT Q2A	35.440	0.000	O
LEBT Q2B	31.093	0.000	O
LEBT M1	31.062	0.000	O
DECK E	17.083	0.000	O
LEBT Q3A	29.158	0.000	O
LEBT Q3B	61.954	0.000	O
LEBT Q3C	66.966	0.000	O
LEBT Q3D	45.433	0.000	O
LEBT SM1H	-0.050	0.000	O
LEBT SM1V	-0.068	0.000	O
LEBT SM2H	0.000	0.000	O
LEBT SM2V	0.003	0.000	O

DRIFT TUBES

0	12.323	0.00	O	15	8.579	0.00	O	30	9.331	0.00	O
1	7.409	0.00	O	16	7.265	0.00	O	31	9.095	0.00	O
2	6.800	0.00	O	17	7.622	0.00	O	32	9.114	0.00	O
3	7.712	0.00	O	18	8.318	0.00	O	33	9.100	0.00	O
4	7.018	0.00	O	19	7.969	0.00	O	34	9.142	0.00	O
5	7.212	0.00	O	20	9.045	0.00	O	35	9.337	0.00	O
6	5.104	0.00	O	21	9.108	0.00	O	36	9.150	0.00	O
7	6.286	0.00	O	22	9.159	0.00	O	37	11.079	0.00	C
8	7.428	0.00	O	23	9.142	0.00	O	38A	7.510	0.00	C
9	8.153	0.00	O	24	9.088	0.00	O	38B	13.178	0.00	O
10	8.367	0.00	O	25	9.022	0.00	O	GR4	410.086	0.00	O
11	7.776	0.00	O	26	9.056	0.00	O	GR5A	542.564	0.00	O
12	8.154	0.00	O	27	9.037	0.00	O	GR5B	477.680	0.00	O
13	8.209	0.00	O	28	8.991	0.00	O	GR6	311.404	0.00	O
14	7.995	0.00	O	29	8.971	0.00	O				

TIMING

3 23 20 1000 80 1000 120 1000 600 400 2

SAVE7 13:26 Ø3/23/87 31+4 S1A#3= 275uA

STATIONS

ARC I	[illegible]	2.447	0
ARC I LIM	1.526	Ø.ØØØ	0
SPUT ARC L	2699.940	2691.Ø88	0
SPUT ARC E L	37.851	36.63Ø	C
EXTRACT E	19.293	19.983	0
EINZEL E	15.756	16.Ø88	0
MAGNET I	24Ø.3Ø8	24Ø.843	0
DECK E	59.ØØØ	58.889	C
LEBT Ø1A	16.245	16.5Ø8	0
LEBT Ø1B	6Ø.232	6Ø.562	0
LEBT Ø2A	115.22Ø	116.Ø44	0
LEBT Ø2B	86.117	85.958	C
LEBT M1	1Ø7.692	1Ø7.643	0
DECK E	59.ØØØ	59.Ø16	C
LEBT Ø3A	113.516	114.969	0
LEBT Ø3B	195.Ø49	197.6Ø7	0
LEBT Ø3C	199.676	199.951	0
LEBT Ø3D	17Ø.8ØØ	188.327	C
LEBT SM1H	Ø.ØØØ	Ø.ØØ3	0
LEBT SM1V	Ø.ØØØ	-Ø.ØØ1	0
LEBT SM2H	Ø.ØØØ	Ø.ØØ5	0
LEBT SM2V	Ø.ØØØ	Ø.ØØ3	C

DRIFT TUBES

Ø	39.572	34.56	0	15	28.ØØØ	27.98	0	3Ø	31.5ØØ	[illegible]	[illegible]
1	22.ØØØ	21.9Ø	0	16	28.ØØØ	28.Ø7	0	31	31.5ØØ	3Ø.49	[illegible]
2	22.ØØØ	21.96	0	17	28.ØØØ	27.97	0	32	31.5ØØ	32.21	[illegible]
3	22.ØØØ	21.92	0	18	28.ØØØ	28.19	0	33	31.5ØØ	32.Ø5	[illegible]
4	22.ØØØ	21.96	0	19	28.ØØØ	28.39	0	34	31.5ØØ	[illegible]	[illegible]
5	22.ØØØ	21.72	0	2Ø	31.5ØØ	31.58	0	35	31.5ØØ	[illegible]	[illegible]
6	22.ØØØ	23.Ø4	0	21	31.5ØØ	31.44	0	36	31.5ØØ	[illegible]	[illegible]
7	22.ØØØ	22.69	0	22	31.5ØØ	31.6Ø	0	37	31.5ØØ	[illegible]	[illegible]
8	22.ØØØ	22.5Ø	0	23	31.5ØØ	31.48	0	38A	[illegible]	[illegible]	[illegible]
9	28.3ØØ	27.94	0	24	31.5ØØ	31.5Ø	0	38B	19.81Ø	[illegible]	[illegible]
1Ø	28.3ØØ	28.18	0	25	31.5ØØ	31.48	0	GR4	[illegible]	[illegible]	[illegible]
11	28.3ØØ	28.12	0	26	31.5ØØ	31.38	0	GR5A	[illegible]	[illegible]	[illegible]
12	28.ØØØ	27.53	0	27	31.5ØØ	[illegible]	0	GR5B	425.ØØ6	[illegible]	[illegible]
13	28.ØØØ	28.Ø9	0	28	31.5ØØ	31.64	0	GR6	549.988	[illegible]	[illegible]
14	28.ØØØ	27.92	0	29	31.5ØØ	31.26	0				

TIMING

[illegible] [illegible] 46 [illegible] [illegible] [illegible] 12Ø 1ØØØ 6ØØ 4ØØ 2

SAVEB 07:32 03/10/87 neon 3+

STATIONS

ARC I	2.600	2.447	O
ARC E LIM	2.747	2.442	O
SPUT ARC E	0.000	0.000	O
SPUT ARC E L	1.526	0.000	C
EXTRACT E	16.470	17.111	O
EINZEL E	17.073	17.661	O
MAGNET I	235.073	235.470	O
DECK E	56.500	55.968	C
LEBT Q1A	1.850	2.442	O
LEBT Q1B	46.856	46.789	O
LEBT Q2A	121.026	121.026	O
LEBT Q2B	101.905	101.587	C
LEBT M1	101.453	101.587	O
DECK E	56.500	56.190	C
LEBT Q3A	98.706	99.731	O
LEBT Q3B	176.551	178.657	O
LEBT Q3C	198.761	199.756	O
LEBT Q3D	166.954	183.150	C
LEBT SM1H	0.000	0.003	O
LEBT SM1V	0.000	0.000	O
LEBT SM2H	0.000	0.006	O
LEBT SM2V	0.200	0.005	C

DRIFT TUBES

0	32.995	33.11	O	15	21.000	20.99	O	30	21.000	21.15	O
1	17.000	16.80	O	16	21.000	21.01	O	31	21.000	20.30	O
2	16.800	16.66	O	17	21.000	20.96	O	32	21.000	21.53	O
3	14.994	14.75	O	18	21.000	21.06	O	33	21.000	21.43	O
4	14.994	14.77	O	19	21.000	21.25	O	34	21.000	20.53	O
5	13.996	13.66	O	20	22.000	22.05	O	35	21.000	21.19	O
6	14.994	15.55	O	21	23.000	22.98	O	36	23.000	22.61	O
7	14.994	15.32	O	22	23.000	23.14	O	37	23.000	23.47	O
8	13.994	14.15	O	23	23.000	23.04	O	38A	35.996	32.49	O
9	14.994	14.73	O	24	23.000	23.05	O	38B	28.000	27.51	O
10	18.000	17.66	O	25	20.000	20.04	O	GR4	600.000	593.31	O
11	22.000	21.88	O	26	20.000	20.05	O	GR5A	500.000	502.47	O
12	21.000	20.64	O	27	20.000	20.09	O	GR5B	424.957	427.64	O
13	21.000	21.03	O	28	20.000	20.08	O	GR6	500.342	487.23	O
14	21.000	20.83	O	29	20.000	19.95	O				

TIMING

18 2 10 1000 80 1000 200 700 500 400 2

SAVE? 14:[illegible] 09/11/86 NEON 4+

STATIONS

ARC I	2.500	2.132	U
ARC E LIM	0.000	0.000	O
SPUT ARC E	0.000	0.000	O
SPUT ARC E L	1.526	0.000	C
EXTRACT E	19.494	20.145	O
EINZEL E	16.000	16.527	O
MAGNET I	210.073	210.623	O
DECK E	43.000	43.238	C
LEBT Q1A	6.227	6.447	O
LEBT Q1B	37.967	37.998	O
LEBT Q2A	92.204	92.405	O
LEBT Q2B	74.585	74.725	C
LEBT M1	75.147	74.921	O
DECK E	43.000	43.397	C
LEBT Q3A	60.769	1.074	O
LEBT Q3B	151.117	1.563	O
LEBT Q3C	191.740	2.247	O
LEBT Q3D	136.050	1.954	C
LEBT SM1H	0.078	0.002	O
LEBT SM1V	0.071	-0.002	O
LEBT SM2H	0.074	0.005	O
LEBT SM2V	0.222	0.003	C

DRIFT TUBES

0	26.000	0.00	O	15	18.000	0.00	O	30	23.000	0.00	O
1	15.995	0.00	O	16	18.000	0.01	O	31	23.000	0.00	O
2	15.995	0.00	O	17	18.000	0.04	O	32	23.000	0.00	O
3	16.629	0.00	O	18	18.000	0.00	O	33	23.000	1.12	O
4	16.122	0.00	O	19	18.000	0.00	O	34	24.000	0.02	O
5	16.715	0.00	O	20	22.000	0.00	O	35	24.000	0.04	O
6	16.888	0.00	O	21	22.000	0.00	O	36	24.000	0.00	O
7	16.826	0.00	O	22	22.000	0.04	O	37	24.000	0.00	O
8	16.278	0.00	O	23	22.000	0.01	O	38A	23.000	0.00	O
9	18.000	0.00	O	24	22.000	0.00	O	38B	25.000	0.00	O
10	18.000	0.00	O	25	22.000	0.02	O	GR4	605.226	0.00	U
11	18.000	0.00	O	26	22.000	0.00	O	GR5A	679.365	0.02	O
12	18.000	0.00	O	27	22.000	0.02	O	GR5B	669.499	0.09	O
13	18.000	0.00	O	28	22.000	0.00	O	GR6	437.827	0.00	O
14	18.000	0.00	O	29	22.000	0.00	O				

TIMING

30 1 20 1100 80 1000 220 1000 600 400 2

4.0 <u>Some Magnet Currents vs Bevalac Field</u>

Presented below are the settings of a given magnet in amps per kilogauss of the Bevalac main field. For example, when the Bevalac's field is at 10 kG, XM4 should be at 850 Amps. This is preliminary data which will eventually be expanded. Also, the ratios of currents in some magnets are given. For example, when XM5 has 1000 amps through it then XM4 should have 2050 amps.

Magnet	Magnet Current/Bev Field Amps/Kilogauss	Current Ratio	Channel
XM4	85.0 ±3	2.05	1
XM5	41.5 ±2	1	1
S1M3	25.0		1
S1M3	23.5		Septum Ch.
S1M4	228	6.16	Septum Ch.
S1M5	87.0	2.35	Septum Ch.
S1M6	37.0	1	Septum Ch.
X1Q4A	159 ±4	0.987	1
X1Q4B	161 ±2	1	or Septum
S1Q7A	116 ±1	0.906	Septum
S1Q7B	128 ±1	1	Septum
XM4	61.5 ±1	2.32	2
XM5	26.5 ±1	1	2

5.0 Some Dipole Tuning Hints

5.1 Extraction Channel: Magnets XM2/XM3.

Horizontally the beam should be centered at following wires

XM2WC wire = 16

XM3WC wire = 29

XM4WC wire = 16

Centering the beam on wire 29 at XM3WC minimizes quadrupole steering by XQ3.

5.2 Channel 1: Magnets XM4/XM5.

Horizontally the beam should be centered at the following wires

X1Q4WC wire = 16

S1M3WC wire = 16

Centering the beam on wire 16 at X1Q4WC minimizes quadrupole steering by X1Q4.

The procedure is as follows:

1. Put in the nominal currents for XM4/XM5 from a previous tune or scaled currents.
2. Adjust the XM5 current to center the beam at S1M3WC, wire = 16. (Do not center on wire 17).
3. Adjust the XM4 current to center the beam at X1Q4WC, wire = 16.
4. Repeat step 2.
5. Repeat step 3, continue to repeat first step 2 then step 3 until the beam is centered on S1M3WC and X1Q4WC.

5.3 Channel 1: Magnets XM3V/XM4V.

Vertically the beam should be centered at X1Q4WC wire = 16. This minimizes quadrupole steering (vertically) by X1Q4.

5.4 Channel 1: Magnet S1M3.

Horizontally the beam should be centered at X1Q5WC, wire = 16 to minimize quadrupole steering by X1Q5.

5.5 Channel 1: Magnet X1M5S.

Vertically we require for the following beam lines:

Beam 26: The beam should be centered on B26WC2, wire 16 to minimize (vertical) quadrupole steering by B26Q1. Do not center the beam vertically on B26 WC1 (wire = 16).

Beam 40: The beam should be centered at wire = 16 at X1Q5WC.

5.6 Beam 26: Magnet X1M6/B26M1

- Horizontally do not center the beam on B26WC1 (wire = 16). This wire chamber is badly misaligned (due to hardware constraints, it is difficult to reorient). Note the wire chamber pictures of B26WC1 in Sec. 3.1.4. Set X1M6 and B26M1 at nominal values from scaling or previous known values.

1. Use X1M6 to center the beam on B26WC2.
2. Use B26M1 to center the beam on B26WC4.
3. Repeat step 1 and then 2 etc. until the beam is centered on both wire chambers.

5.7 Septum Channel: Magnet S1M3.

Horizontally the beam should be centered at:

S1F2WC, wire = 35

This maximizes the angular acceptance in the downstream magnets S1M4, S1M5, S1M6. Note: the ratio of the horizontal to vertical beam size at F2 is 3 to 1. Do not try to make the horizontal and vertical beams sizes the same (See Sec. 3.7.3)

5.8 Septum Channel: Magnets S1M4/S1M5/S1M6.

Horizontally the beam should be centered on

S1M6WC, wire = 16

S1Q7WC, wire = 16

S1F2WC, wire = 16

The procedure is as follows:

1. Put in the nominal currents (previously saved or scaled) for S1M4/S1M5/S1M6.
2. Adjust the S1M6 current to center the beam at S1F2WC, wire = 16.
3. Adjust the S1M5 current to center the beam at S1Q7WC, wire = 16.
4. Repeat step 2 and then step 3 until wire position conditions are satisfied.
5. Adjust the S1M4 current to center the beam at S1M6WC, wire = 16.
6. Now repeat step 2 and step 3.
7. Repeat step 5. Discontinue when all conditions are met.

5.9 Septum Channel: Magnet S1M5S.

Vertically the beam should be centered at

S1Q7WC, wire = 16

to minimize (vertical) quad steering in S1Q7.

5.10 Channel 2: Magnets XM4/XM5

Horizontally the beam should be centered at the following wires

X2Q4WC wire = 16

X2F2WC wire = 16

Centering the beam on wire 16 at X2Q4WC minimizes quadrupole steering by X2Q4.

The procedure is as follows:

1. Put in the nominal currents for XM4/XM5 from a previous tune or scaled currents.
2. Adjust the XM5 current to center the beam at X2F2WC, wire = 16.
3. Adjust the XM4 current to center the beam at X2Q4WC, wire = 16.
4. Repeat Step 2.
5. Repeat Sept 3, continue to repeat <u>first</u> Step 2 then Step 3 until the beam is centered on X2F2WC and X2Q4WC.

This procedure is the same as in Channel 1 (see Section 5.2) but will require more iterations since X2Q4WC is further downstream of XM5, then X1Q4WC.

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