

APPENDIX B

APPENDIX B.

TEVATRON I
PARAMETER BANK

(AR2)

(FERMILAB, JUNE 1983)

- A. MAIN RING
- B. TARGETRY
- C. TRANSPORT LINES
- D. DEBUNCHER RING
- E. ACCUMULATOR RING
- F. SUPERCONDUCTING RING
- G. COLLIDER AT B0
- H. COLLIDER AT D0
- I. SYNCH FILES

TABLES OF TEVATRON I PARAMETERS

A. MAIN RING

AA. GENERAL MAIN RING PARAMETERS

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AB.2 PROTON ACCELERATION TO 120 GEV

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AB.4 PROTON EXTRACTION AT 120 GEV

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AC.2 ACCELERATION TO 150 GEV

AC.3 BUNCH RECOMBINATION FOR COLLIDER

AC.4 EXTRACTION AT 150 GEV

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BA. PROTON TRANSPORT TO TARGET (SEE CA)

BB. TARGET

BB.1 TARGETRY

BB.2 TARGET ENERGY DEPOSITION

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BC.1 LITHIUM LENS

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BD. ANTIPROTON TRANSPORT TO DEBUNCHER (SEE CB)

BE. DUMP

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CA. PROTONS, MAIN RING TO TARGET

CA.1 MAGNETS

CA.2 LATTICE STRUCTURE

CA.3 LATTICE FUNCTIONS

CA.4 APERTURE REQUIREMENTS

CA.5 X,Y,Z SITE COORDINATES

CB. ANTIPROTONS, TARGET TO DEBUNCHER

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CB.2 LATTICE STRUCTURE

CB.3 LATTICE FUNCTIONS

CB.4 APERTURE REQUIREMENTS

CB.5 X,Y,Z SITE COORDINATES

CC. ANTIPROTONS, DEBUNCHER TO ACCUMULATOR RING

CC.1 MAGNETS

CC.2 LATTICE STRUCTURE

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CC.4 APERTURE REQUIREMENTS

CC.5 X,Y,Z SITE COORDINATES

CD. ANTIPROTONS, ACCUMULATOR RING TO MAIN RING

CD.1 MAGNETS

CD.2 LATTICE STRUCTURE

CD.3 LATTICE FUNCTIONS

CD.4 APERTURE REQUIREMENTS

CD.5 X,Y,Z SITE COORDINATES

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CF.2 LATTICE STRUCTURE

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CF.5 X,Y,Z SITE COORDINATES

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CG.1 MAGNETS

CG.2 LATTICE STRUCTURE

CG.3 LATTICE FUNCTIONS

CG.4 APERTURE REQUIREMENTS

CG.5 X,Y,Z SITE COORDINATES

D. DEBUNCHER

DA. INJECTION TO DEBUNCHER RING

DA.1 LATTICE AND PARAMETERS

DA.2 MAGNETS AND DRIFTS

DA.3 LAMBERTSON MAGNET

DA.4 KICKER MAGNET

DB. LATTICE

DB.1 GENERAL

DB.2 MAGNETS

DB.3 DRIFTS (EFFECTIVE)

DB.4 LATTICE STRUCTURE

DB.5 LATTICE FUNCTIONS

DB.6 APERTURE REQUIREMENTS

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DC.1 DIPOLES

DC.2 QUADRUPOLES

DC.3 SEXTUPOLES

DD. VACUUM

DE. RF

DF. STOCHASTIC COOLING

DG. EXTRACTION

DH. TRANSFER FROM DEBUNCHER RING TO ACCUMULATOR RING

E. ACCUMULATOR

EA. TRANSFER FROM DEBUNCHER RING TO ACCUMULATOR RING

EB. INJECTION TO ACCUMULATOR RING

EC. LATTICE

EC.1 GENERAL

EC.2 MAGNETS

EC.3 DRIFTS (EFFECTIVE)

EC.4 LATTICE STRUCTURE

EC.5 LATTICE FUNCTIONS

EC.6 APERTURE REQUIREMENTS

ED. MAGNETS

ED.1 DIPOLES

ED.2 QUADRUPOLES

ED.3 SEXTUPOLES

ED.4 OCTUPOLES

EE. VACUUM

EF. RF

EG. STOCHASTIC COOLING

EG.1 MOMENTUM TAIL COOLING SYSTEM

EG.2 MOMENTUM CORE COOLING SYSTEM

EG.3 BETATRON TAIL COOLING SYSTEMS

EG.4 BETATRON CORE COOLING SYSTEMS

EH. EXTRACTION

F. SUPERCONDUCTING RING

FA. TRANSFER FROM MAIN RING

FB. INJECTION TO SUPERCONDUCTING RING

FC. LATTICE

FD. MAGNETS

FE. VACUUM

FF. RF

FG. ABORT

G. BO COLLIDER

GA. LOW BETA INSERTION

GB. PERFORMANCE PARAMETERS

GC. EXPERIMENTAL AREAS

H. DO COLLIDER

HA. LOW BETA INSERTION

HB. PERFORMANCE PARAMETERS

HC. EXPERIMENTAL AREAS

I. SYNCH FILES

THE TABLES

TO SEE IF THE TABLES HAVE BEEN UPDATED SINCE THIS PRINTING:

1. LOG-ON THE CYBER ON YOUR OWN DISK AREA AT ANY TERMINAL.
2. TYPE: G,PARAM/UN=94669
PARAM
3. FOLLOW INSTRUCTIONS APPEARING ON THE SCREEN.

ASSUME OVERPASS (SEE AE)

	<u>INJECTION</u>	<u>MAXIMUM</u>
KINETIC ENERGY, GEV	8.0	200
BETA	0.994475	0.999989
GAMMA	9.5262	214.16
MOMENTUM, GEV/C	8.8889	200.94
MAGNETIC RIGIDITY, TM	29.65	670.3
DIPOLE FIELD STRENGTH, T	0.0397	0.896
QUADRUPOLE FIELD GRADIENT, T/M	0.534	12.07
BETATRON TUNES (H & V)	19.4	
TRANSITION ENERGY (GAMMA/T)	18.75	
AVERAGE RADIUS, M	1000.0	
DIPOLE BENDING RADIUS, M	747.8	
HORIZONTAL BETATRON ACCEPTANCE	3.0 PI.MM.MRAD	
VERTICAL BETATRON ACCEPTANCE	2.5 PI.MM.MRAD	
MOMENTUM APERTURE, DP/P	+- 0.3 %	+- .35 %
REVOLUTION PERIOD, MICROSEC	21.075	20.959
MAX. DISPERSION, HOR. (M)	6.	
VERT. (M)	0.5	
MAX. BETA VALUE, M	120.	
PERIODICITY	NONE	
PHASE ADVANCE/REGULAR CELL	70 DEG	
STANDARD RF FREQUENCY, MHZ	52.8117	53.1045
HARMONIC NUMBER (H)	1113	
MAX. RF VOLTAGE, MV	4.0	

AB.1 INJECTION FROM THE BOOSTER

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INJECTION KINETIC ENERGY	8.0 GEV
BETA	0.994475
GAMMA	9.5262
MOMENTUM	8.8889 GEV/C
MAGNETIC RIGIDITY	29.65 TM
NO. OF BOOSTER BATCHES INJECTED	ONE
MODE OF TRANSFER	SINGLE-TURN EXTRACTION FROM BOOSTER AND INJECTION TO MAIN RING, BUCKET-TO-BUCKET
BETATRON EMITTANCE (H & V, 95 % OF BEAM)	2.5 PI.MM.MRAD
NO. OF BUNCHES	80
NO. OF PROTONS/BUNCH	2.5E+10
NO. OF PROTONS/PULSE	2.0E+12
INDIVIDUAL BUNCH AREA (95 % OF BEAM)	0.1 - .15 EV.SEC
RF FREQUENCY	52.8117 MHZ
RF VOLTAGE	1.2 MV
BUCKET AREA, STATIONARY	0.66 EV.SEC
BUCKET HEIGHT, DP/P	+ - .31 %

AB.2

PROTON ACCELERATION TO 120 GEV

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KINETIC ENERGY, GEV	8.0	120.
TRANSITION KINETIC ENERGY, GEV	16.65	
REVOLUTION FREQUENCY, KHZ	47.451	47.712
HARMONIC NUMBER	1113	
RF FREQUENCY, MHZ	52.812	53.1035
RF VOLTAGE, MV	1.2	.75
ACCELERATION RATE, MAX, GEV/S	125	
SYNCHROTRON PHASE ANGLE	0 - 50 DEG	130 - 135 DEG
BUCKET AREA, EV.SEC	0.66	3.3
INDIVIDUAL BUNCH AREA AT 120 GEV (95 % OF BEAM) EV.SEC	0.2	
MAIN RING CYCLE PERIOD:	2.0 SEC	
FRONT PORCH	0.1 SEC	
ACCELERATION TO 120 GEV	1.2 SEC	
FLAT TOP	0.2 SEC	
FALL OFF PERIOD	0.5 SEC	

MAIN RING CYCLE PERIOD	2 SEC
KINETIC ENERGY AT FLAT-TOP	120 GEV
FLAT-TOP LENGTH	0.2 SEC
TRANSITION ENERGY (GAMMA/T)	18.75
RF FREQUENCY	53.1035 MHZ
HARMONIC NUMBER (H)	1113
(1) END OF ACCELERATION	STATIONARY BUCKET
RF VOLTAGE	.68 MV
PHASE OSCILLATION PERIOD	12.8 MSEC
BUCKET AREA	3.8 EV.SEC
BUNCH LENGTH (95 %)	79 CM
MOMENTUM SPREAD, DP/P (95 %)	4.2E-4
(2) RF VOLTAGE REDUCED SLOWLY TO	12 KV
TIME PERIOD FOR ADIABATIC REDUCTION	0.1 SEC
FINAL BUCKET AREA	0.46 EV.SEC
FINAL PHASE OSCILLATION PERIOD	105 MSEC
FINAL BUNCH LENGTH	2.82 M
FINAL MOMENTUM SPREAD, DP/P	2.5E-4
FINAL RF PHASE EXTENSION OF BUNCH	+90 DEG
(3) FAST INCREASE OF RF VOLTAGE TO	4MV
IN A PERIOD OF TIME OF	40 MUSEC
90 DEG BUNCH ROTATION PERIOD	1.4 MSEC
EQUIVALENT TO PHASE OSCILLATION PERIOD	5.5 MSEC
BUNCH LENGTH, AT END OF ROTATION	LESS THAN 30 CM
RMS MOMENTUM SPREAD, DP/P	4.1E-3
(4) BEAM EXTRACTION	FAST: AS SOON AS BUNCHES HAVE ROTATED BY 90 DEG

EXTRACTION KINETIC ENERGY	120 GEV
MAGNETIC RIGIDITY (B-RHO)	403.27 T.M
BEAM PULSE LENGTH TO BE EXTRACTED	21 MICROSEC
REVOLUTION PERIOD	20 MICROSEC
BEAM EMITTANCE AT EXTRACTION (H & V, 95% OF BEAM)	0.2 PI.MM-MRAD
BEAM FULL MOMENTUM SPREAD AT EXTRACTION, 95% OF BEAM	0.4%
EXTRACTION MODE: (A) 4-MAGNET LOCAL HORIZ. BUMP CENTERED AT F17 (B) HORIZONTAL KICK OUTWARD (C) LAMBERTSON MAGNETS FOR VERTICAL EXTRACTION.	
HORIZONTAL DISPLACEMENT AT F17 WITH 4-MAGNET BUMP	+ - 37 MM
KICKER LOCATION	C48
HORIZONTAL DISPLACEMENT BY KICKER AT F17	+43 MM
ANGULAR DISPLACEMENT BY KICKER AT F17	+0.847 MRAD
LOCATION OF LAMBERTSON	F17
NUMBER OF LAMBERTSON MAGNETS	2
LAMBERTSON MAGNET LENGTH / EACH	204 INCHES
LAMBERTSON MAGNET FIELD STRENGTH	13 KG

CONTINUED

AB.4 (CONTINUED)

HORIZONTAL PLANE LATTICE FUNCTIONS:

LOCATION	BETA (M)	ALPHA	PHASE RELATIVE TO F17 (MODULO 360 DEG)	SPACE AVAILABLE (IN.)
C48 KICKER	102.414	0.46696	-90.11 DEG	(EXISTING)
F12	29.601	-0.5731	-168.30 DEG	0.0
F13	95.356	1.8584	-135.74 DEG	0.0
F14	28.383	-0.5893	-99.29 DEG	34.0
F15 (BUMP 1)	97.247	1.8396	-66.32 DEG	42.5
F16	30.093	-0.6239	-31.47 DEG	42.0
F17 (BUMP 2) (EXTRACTION)	99.648	1.9388	0.00 DEG	32.0
F18 (BUMP 3)	28.865	-0.5582	35.20 DEG	52.0
F19	94.322	1.8156	68.42 DEG	0.0
F21	28.912	-0.6177	104.71 DEG	28.0
F22 (BUMP 4)	99.541	1.8926	136.92 DEG	27.5
F23	30.073	-0.5983	171.32 DEG	35.0
F24	97.400	1.9056	203.21 DEG	0.0
F25	28.365	-0.5666	239.23 DEG	35.0
F26	95.244	1.8100	272.60 DEG	43.5

INJECTION KINETIC ENERGY	8.0 GEV
REVOLUTION FREQUENCY	47.451 KHZ
HARMONIC NUMBER	1113
RF FREQUENCY	52.813 MHZ
RF VOLTAGE	1.2 MV
RF BUCKET AREA	0.66 EV.SEC
RF BUCKET HEIGHT, DP/P	+ - .31 %
NO. OF BOOSTER BATCHES INJECTED	3, EQUALLY SPACED
MODE OF TRANSFER	SINGLE-TURN EXTRACTION FROM BOOSTER AND INJECTION TO MAIN RING OF A SINGLE BATCH, BUNCH-TO-BUCKET
NO. OF BUNCHES/BATCH	7, SELECTED NEXT TO EACH OTHER, AFTER REMOVING UNWANTED BUNCHES WITH SUPERDAMPER
NO. OF PROTONS/BUNCH	1.2E+10
NO. OF PROTONS/BATCH	8E+10
INDIVIDUAL BUNCH AREA (95 % OF BEAM)	0.1 EV.SEC
BETATRON EMITTANCE (H & V, 95 % OF BEAM)	2.5 PI.MM.MRAD
MAIN RING FRONT PORCH PERIOD	0.3 SEC

AC.2

ACCELERATION TO 150 GEV

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KINETIC ENERGY	8.0	150.	GEV
TRANSITION KINETIC ENERGY		16.65	GEV
REVOLUTION FREQUENCY	47.451	47.71	KHZ
HARMONIC NUMBER		1113	
RF FREQUENCY	52.813	53.105	MHZ
RF VOLTAGE	1.2	.68	MV
SYNCHRONOUS PHASE ANGLE	0 - 50	130 - 135	DEG
ACCELERATION RATE, MAX		125	GEV/SEC
ACCELERATION TIME		2.0	SEC
BETATRON EMITTANCE (H & V 95 % OF BEAM)	2.5	0.15	PI.MM.MRAD
INDIVIDUAL BUNCH AREA (95 % OF BEAM)	0.15	0.2	EV.SEC
STATIONARY BUCKET AREA	0.66	3.5	EV.SEC
BUCKET HEIGHT, DP/P	+-.31 %	+-.1 %	
PHASE OSCILLATION PERIOD	1.65	14	MSEC

KINETIC ENERGY 150 GEV

RF VOLTAGE	INITIAL	FINAL
H=53	3.93E+2	3.93E+2
H=1113	6.8E+5	1.0E+2

RF FREQUENCY

H=53	2.53 MHZ
H=1113	53.105 MHZ

NUMBER OF BUNCHES

H=53	1
H=1113	7

RECOMBINATION TIME .8 SEC

BUNCH EMITTANCE APPROX. 1 EVS

BUNCH LENGTH 39.5 M

MOMENTUM SPREAD (APPROX. 95%) 6.7E-5

KINETIC ENERGY 150 GEV

RF VOLTAGE

H=53 45 KV

H=106 -9.8 KV

BUNCH ROTATION TIME

79 MS

FINAL EMITTANCE (EQUIVALENT 95% ELLIPSE)

(LESS THAN 1.5 EVS)

RF VOLTAGE AT EXTRACTION (H=1113)

1.0 MV

BUNCH WIDTH (95%)

2.3 M

BUNCH HEIGHT DP/P (95%)

1.6E-3

KINETIC ENERGY 8.0 GEV

RF VOLTAGE

H=53 2 KV

H=1113 3 KV

RF FREQUENCY

H=53 2.5148 MHZ

H=1113 52.8117 MHZ

MODE OF TRANSFER - SINGLE TURN EXTRACTION FROM ACCUMULATOR

- SYNCHRONOUS INJECTION INTO MAIN RING H=53 BUCKETS

NUMBER OF BUNCHES

1

BUNCH EMITTANCE

1.5 EVS (OR 1.5 - 2 EVS)

BUNCH INTENSITY

8E+10 (OR 8E+10 - E+11)

BUNCH LENGTH

73.4 M

BUNCH HEIGHT DP/P (95%)

8.710E-4

TRANSVERSE EMITTANCE (H & V)

2.5 PI MM MRAD

KINETIC ENERGY 8 GEV

RF VOLTAGE	INITIAL	FINAL
H=53	2 KV	2 KV
H=1113	3 KV	500 KV

RF FREQUENCY

H=53	2.5148 MHZ
H=1113	52.8117 MHZ

NUMBER OF BUNCHES	1	13
ANTIPROTONS/BUNCH	8E+10	8E+9
BUNCH LONG EMITTANCE	1.5	.15 MAX EVS
BUNCH LENGTH	73.4 M	2.54 M
BUNCH HEIGHT		
DP/P (95%)	8.7E-4	2.6E-3

AD.3

ACCELERATION TO 150 GEV

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	INITIAL	FINAL
KINECTIC ENERGY	8.0	150.00
TRANSITION ENERGY		16.65 GEV
REVOLUTION FREQUENCY	47.451	47.71
HARMONIC NUMBER		1113
RF FREQUENCY	52.813	53.1035
RF VOLTAGE	1.2 MV	.68 MV
SYNCHRONOUS PHASE	0-50 DEGREES	130-180 DEGREES
ACCELERATION RATE (MAX)		125 GEV
ACCELERATION TIME		2.0 SEC
TRANSVERSE EMITTANCE (95%)	2.5	.15 PI MM MRAD
INDIVIDUAL BUNCH AREA (MAX)	.15	.2 EVS
BUCKET HEIGHT DP/P (95%)	+.31%	+.1%
PHASE OSCILLATION PERIOD	1.5 M SEC	14 M SEC

KINETIC ENERGY		150 GEV
ROTATION FREQUENCY		47.71 KHZ
RF FREQUENCY		
H=53		2.53 MHZ
H=1113		53.105 MHZ
RF VOLTAGE	INITIAL	FINAL
H=53	98 V	98 V
H=1113	6.8E+5 V	APPROX. 100 V
NUMBER OF BUNCHES		
H=53		1
H=1113	13	
RECOMBINATION TIME		.8 S
BUNCH EMITTANCE		APPROX. 2 EVS
BUNCH LENGTH		73.4 M
MOMENTUM SPREAD		
(95% DP/P)		6.9E-5

KINETIC ENERGY	150 GEV
RF FREQUENCY	
H=53	2.529 MHZ
H=106	5.058 MHZ
RF VOLTAGE	
H=53	20 KV
H=106	-4.4 KV
BUNCH ROTATION TIME	115 MS
FINAL EMITTANCE	
(95% EQUIVALENT ELLIPSE)	LESS THAN APPROX. 3 EVS
RF VOLTAGE AT EXTRACTION	1.0 MV
H=1113	
BUNCH WIDTH 95%	3.93 M
BUNCH HEIGHT	
(95% DP/P)	2.2E-3

TARGET MATERIAL	TUNGSTEN-RHENIUM
LENGTH OF TARGET	6 CM
TARGET DISK	8 CM
PROTON BEAM:	
BETA.STAR, PROTON (H & V)	4.6 M
ALPHA.STAR, PROTON (H & V)	0.
ETA.STAR, PROTON (DISPERSION)	0. M
ETA.PRIME.STAR, PROTON	0.
PROTON RMS SPOT SIZE (H & V)	0.39 MM
NO. OF BOOSTER BATCHES / M R CYCLE	ONE
TIME INTERVAL BETWEEN BATCHES	2.0 SEC
MAIN RING CYCLE TIME	2.0 SEC
NUMBER OF PROTONS / BATCH	1.8E+12
NUMBER OF PROTON BUNCHES / BATCH	80
ANTIPROTON BEAM:	
ANTIPROTON PRODUCTION MOMENTUM	8.889 GEV/C
KINETIC ENERGY	8.0 GEV
BETA	0.99448 M
GAMMA	9.5264 1/M
MAGNETIC RIGIDITY (B-RHO)	29.65 T.M
MOMENTUM SPREAD ACCEPTED, FULL DELTA P/P,	3%

CONTINUED

BB.1 (CONTINUED)

EMITTANCE ACCEPTED (H & V)	20 PI.MM-MRAD
AVERAGE ANTIPROTON ANGLE	23.8MRAD
BETA.STAR, ANTIPROTON (H & V)	0.11 M
ANTIPROTON SPOT SIZE (H & V)	1.5 MM
PBAR PRODUCTION CROSS-SECTION, $D3N/DPD\Omega=0.252$ PBARS/(GEV/C) STER.INT.P	
ANTIPROTON ABSORPTION LENGTH	9.29 CM
PROTON ABSORPTION LENGTH	9.86 CM
CALCULATED ANTIPROTONS/PROTONS	3.7E-5
TOTAL NUMBER OF ANTIPROTONS / M R CYCLE	6.7E+7
NUMBER OF ANTIPROTON BUNCHES / M R CYCLE	80
NUMBER OF ANTIPROTONS / BUNCH	8.4E+5
ANTIPROTON BUNCH LENGTH (AT TARGET, RMS)	5 CM
ANTIPROTON BUNCH AREA (95% OF BEAM)	0.24 EV.SEC
PROTON BUNCH TIMING	18.83115 NSEC
ANTIPROTON BUNCH TIMING	SAME
PROTON BUNCH SPACING (CENTER-TO-CENTER)	5.64527 M
ANTIPROTON BUNCH SPACING	5.61427 M
ANTIPROTON BUNCHING FREQUENCY	53.1035 MHZ

TARGET MATERIAL	TUNGSTEN/TUNGSTEN ALLOYS
LENGTH	6 CM
120 GEV PROTONS/PULSE	1.8+12
TOTAL BEAM ENERGY	3.46E+4 JOULES
REPETITION RATE	0.5 HZ
BEAM PULSE DURATION	1.6E-6 SEC
ENERGY DEPOSITED/PROTON GEV	1.26 GEV (1.82E-10 JOULES)
ENERGY DEPOSITED/PULSE	346 JOULES
AVERAGE ENERGY DEPOSITED	173 WATTS
AVERAGE TEMPERATURE	LESS THAN 100 DEG C
PROTON RMS BEAM SIZE (H & V)	0.39 MM
PEAK ENERGY DENSITY/PROTON	13.4 GEV/CM3
PEAK ENERGY DENSITY/PULSE	200 JOULES/GM
PEAK TEMPERATURE RISE	LESS THAN 1500 DEG C

TRANSFORMER:

OVERALL DIAMETER	42 CM
OVERALL LENGTH	24 CM
I.D. OF PRIMARY	16 CM
CORE AREA	154 SQ CM

LITHIUM LENS:

OVERALL DIAMETER	9 CM
OVERALL LENGTH	24 CM
LITHIUM CONDUCTOR DIAMETER	2 CM
LENGTH	15 CM
BERYLLIUM WINDOW THICKNESS	0.5 CM
TITANIUM COOLING JACKET THICKNESS	0.1 CM

TRANSFORMER (PRIMARY):

RESISTANCE	.49 MILLIOHM
STRAY INDUCTANCE	.44 MICRO. H
NO. OF TURNS	8

LI LENS & TRANSFORMER (SECONDARY):

RESISTANCE	.126 MILLIOHM
INDUCTANCE	31 NANO. H

REFLECTED PRIMARY CIRCUIT PARAMETERS:

RESISTANCE	8.6 MILLIOHM
INDUCTANCE	2.4 MICRO. H
DAMPING FACTOR ALPHA = $R/2L$	1780 HZ

PULSED POWER SUPPLY:

PULSE LENGTH	0.33 MSEC
VOLTAGE	2.5 KV
CAPACITANCE	4600 MICRO F
INITIAL STORED ENERGY	14.4 KJ
REPITION RATE	0.5 HZ

TRANSFORMER (PRIMARY):

PEAK CURRENT	83 KA
DISSIPATED ENERGY/PULSE	570 J
DISSIPATED POWER	290W
NET MAGNETIC FORCE ON PRIMARY TURNS	7700 LBS
CORE BIAS	10 A

LITHIUM LENS & TRANSFORMER (SECONDARY):

PEAK CURRENT	670 KA
DISSIPATED ENERGY/PULSE	9800 J
DISSIPATED POWER	4.9 KW
NET AXIAL MAGNETIC FORCE ON LENS	33000 LBS
TEMP RISE/PULSE	120 DEG C (MAX)
	35 DEG C (MIN)

MAGNETIC FIELD (LITHIUM):

AC SKIN DEPTH	.45 CM
PEAK SURFACE FIELD	13.5 T
PHASE AT BEAM TIME	117 DEG
AVE. FIELD GRADIENT AT BEAM TIME	1100 T/M
PEAK MAGNETIC PRESSURE	16000 PSI
AVE. NON-LINEARITY	2.8 %

KINETIC ENERGY AT INJECTION 8.0 GEV
MOMENTUM 8.8889 GEV/C
MAGNETIC RIGIDITY 296.501 KG-M
EMITTANCE INJECTED (H & V) 20 PI.MM.MRAD
MOMENTUM SPREAD INJECTED,
FULL DP/P, MAX, 4 %

METHOD: VERTICAL INJECTION ON A HORIZONTALLY
CENTERED ORBIT, FOLLOWED
BY KICKING ON REFERENCE PLANE

STRING OF ELEMENTS:

FROM THE UPSTREAM END OF COMMON QUAD QF3
TO THE DOWNSTREAM END OF THE KICKER (KICK)

QF3 OS SM S1 QD2 LA QF2 O1 KICK

LOCATION OF THE LAMBERTSON (SM) STATION D4-4

LOCATION OF THE KICKER (KICK) STATION D4-2

DRIFT ELEMENTS	LENGTH
S1	1.2929 M
O1	0.4636 M
LA	3.731264 M
OS	0.3048 M

SEE ALSO TABLES DB.3 AND DB.4

QUADRUPOLES:	EFFECTIVE LENGTH	B'/(B.RHO)	BORE RADIUS
QF3	0.8280 M	0.32494 1/M**2	8.41 CM
QD2	0.7010 M	-0.38679 1/M**2	4.45 CM
QF2	0.7010 M	0.35881 1/M**2	4.45 CM

SEE ALSO TABLES DB.2 AND DC.2

LOCATION	STATION D4-4		
EFFECTIVE LENGTH	2.1336 M		
BENDING FIELD	5.6335 KG		
BENDING ANGLE	40.5384 MRAD		
BENDING RADIUS	52.6316 M		
BEAM HORIZONTAL DISPLACEMENT FROM REFERENCE ORBIT	CENTERED WITH REFERENCE ORBIT		
BEAM VERTICAL DISPLACEMENT FROM REFERENCE ORBIT:	BEAM VERTICAL ANGLE FROM REFERENCE ORBIT:		
UPSTREAM QF3	13.4 CM		64.4 MRAD
DOWNSTREAM QF3	9.1 CM		35.4 MRAD
UPSTREAM SM	8.0 CM		35.4 MRAD
DOWNSTREAM SM	4.8 CM		-5.2 MRAD
UPSTREAM QD2	5.5 CM		-5.2 MRAD
DOWNSTREAM QD2	5.3 CM		9.7 MRAD
MAX. FULL BEAM SIZE (H X V) IN THE SEPTUM MAGNET	35 X 26 MM**2		
MIN. SEPARATION BETWEEN INJECTED AND CIRCULATING BEAMS EDGE TO EDGE	22 MM		
APERTURE	5.0 CM (H) X 10.0 CM (V)		

LOCATION	STATION D4-2
EFFECTIVE LENGTH	3.048 M
BENDING ANGLE (HORIZONTAL)	6.17 MRAD
BENDING FIELD	600 G
FALL-OFF TIME	200 NSEC
BEAM VERTICAL DISPLACEMENT:	
UPSTREAM	9.4 MM
DOWNSTREAM	0.0 MM
APERTURE, FULL	4.0 CM (H) X 5.4 CM (V)

KINETIC ENERGY	8.0 GEV
BETA	0.99448
GAMMA	9.5264
MOMENTUM (P)	8.8889 GEV/C
MAGNETIC RIGIDITY (B-RHO)	296.5 KG.M
BENDING FIELD (B)	17.0 KG
BENDING RADIUS (RHO)	17.44 M
AVERAGE RADIUS (R)	80.4182 M
REVOLUTION PERIOD	1.6948 MICROSEC
PACKING FACTOR (RHO/R)	21.7%
SUPERPERIODICITY	3
RF HARMONIC NUMBER (H)	90
FOCUSSING STRUCTURE	SEPARATED FUNCTIONS
NORMAL CELL STRUCTURE	FODO
HORIZONTAL BETATRON TUNE	9.73
VERTICAL BETATRON TUNE	9.77
TRANSITION ENERGY (GAMMA/T)	7.648
$\text{ETA} = 1/(\text{GAMMA/T})^{**2} - 1/\text{GAMMA}^{**2}$	0.0061
NATURAL CHROMATICITY: HORIZONTAL	-10.8
VERTICAL	-11.0

DIPOLES	EFFECTIVE LENGTH	STRENGTH	NUMBER
B	1.6604 M	17.0 KG	66

QUADRUPOLES	EFFECTIVE LENGTH	B'/(B-RHO)	NUMBER
QF	0.701 M	0.33652	42
QD	0.701	-0.32928	39
QF1	0.701	0.37747	3
QD1	0.701	-0.34714	6
QF2	0.701	0.35881	6
QD2	0.701	-0.38679	6
QF3	0.828	0.32494	6
QD3	0.828	-0.32459	6

SEXTUPOLES	EFFECTIVE LENGTH	B''/(B-RHO)(*)	NUMBER
SF	0.2 M	0.70365 1/M**2	36
SD	0.2	-1.0671	33

(*) STRENGTHS REQUIRED FOR CHROMATICITY CANCELLATION IN BOTH PLANES

DB.3

LATTICE DRIFTS (EFFECTIVE)

13.15.19.

CHANGED 5/18/83
PRINTED 5/31/83

O	0.735431 M
OO	1.035431
OS	0.300000
LA	3.731264
LB	3.667764
LC	3.131264
LZ	3.604264

REGULAR CELL (*)

(.C)	QF/2	.OF1	B	.OD2	QD
		.OD1	B	.OF2	QF/2

WHERE

.OF1 = OS	SF	0
.OD1 = OS	SD	0
.OF2 = 0	SF	OS
.OD2 = 0	SD	OS

HALF REGULAR CELL (*)

(.CH)	QF/2	.OF1	B	.OD2	QD/2
-------	------	------	---	------	------

SPECIAL CELLS FOR DISPERSION KILLER (*)

(.C1)	QF/2	OO	B	OO	QD
		OO	B	.OF2	QF/2
(.CS)	QF/2	.OF1	LC	.OD2	QD
		.OD1	LC	.OF2	QF/2

SPECIAL CELLS FOR LONG STRAIGHT SECTIONS (*)

(.CS1)	QF1/2	LA	QD1	LA	QF2/2
(.CS2)	QF2/2	LA	QD2	LB	QF3/2
(.CS3)	QF3/2	LZ	QD3	LB	QF/2

HALF OF A SUPERPERIOD STRUCTURE:

.CS1	.CS2	.CS3	.C1	.CS
.C	.C	.C	.C	.CH

SUPERPERIOD STRUCTURE:

.CS + MIRROR REFLECTION OF .CS

(*) QX/2 DENOTES HALF OF A REGULAR QX QUAD

	BETA/H	BETA/V	ETA
MAXIMA	17.83 M	16.94 M	2.09 M
REGULAR CELL(*):			
MAX	14.97	14.88	2.09
MIN	5.24	5.23	1.28 (**)
QF1 (MAX)	17.83	5.73	-0.0009
QD1	4.79	16.94	-0.0004
QF2	11.81	5.32	-0.0003
QD2	4.44	13.64	0.0001
QF3	17.60	3.52	0.0007
QD3	5.74	13.82	0.0005

(*) INCLUDES DISPERSION KILLER

(**) EXCLUDES DISPERSION KILLER WHERE $ETA/MIN = 0.0 M$

BETATRON ACCEPTANCE: HORIZONTAL 20.PI MM-MRAD

VERTICAL 20.PI MM-MRAD

MOMENTUM APERTURE: +- 2%

MAXIMUM BEAM DIMENSIONS (FULL):

	HORIZ. (MM)	VERTICAL (MM)
B	101.54	32.66
QF	118.14	20.43
QD	73.36	34.50
QF1	36.88	21.96
QD1	20.23	36.82
QF2	30.73	20.64
QD2	18.86	33.04
QF3	37.54	16.78
QD3	21.44	33.24

EFFECTIVE ARC LENGTH	1.660402 M
BENDING RADIUS	17.4412353 M
IRON LENGTH	62.8 INCHES
BENDING ANGLE	95.20 MRAD
FULL GAP	60 MM
GOOD FIELD WIDTH	100 MM
SAGITTA	2.0 CM
CONDUCTOR:	
1" X 1.25" CROSS SECTION	0.375" CROSS SECTION HOLE DIAMETER
1/16" CORNER RADIUS	1.1362 SQ. IN. AREA
URNS:	
PANCAKE COILS	56
SADDLE COILS	16
CONDUCTOR LENGTHS:	
PANCAKE COILS	9740.3"/MAGNET
SADDLE COILS	3680.45"/MAGNET
TOTAL CONDUCTOR LENGTH	13420.75"/MAGNET
COIL PROTRUSION/END	11"
CU WEIGHT/MAGNET	4906.625 LBS
TOTAL CU WEIGHT	161.92 TONS
RESISTANCE/MAGNET (43 DEG C)	8.73 MILLI-OHM
CURRENT AT 1.7T	1175.6 A
VOLTAGE AT 1.7T	10.3 V
POWER/MAGNET	12.065 KW
TOTAL POWER/DIPOLES	0.7963 MW
FULL CROSS SECTION (W X H)	45.25" X 29"
LAMINATION THICKNESS	0.0598"
IRON WEIGHT/MAGNET	16826.865 LBS
TOTAL IRON WEIGHT	555.3 TONS
COOLING WATER PRESSURE	42 PSI
WATER FLOW	2.4 GALLONS/MIN.

TYPE	REGULAR	LONG-SMALL APERTURE	LONG-LARGE APERTURE
EFFECTIVE LENGTH	27.6"	32.6"	32.6"
IRON LENGTH	26.18"	31.18"	30"
POLETIP RADIUS	44.5 MM	44.5 MM	84.1 MM
CONDUCTOR:	0.312"X 0.75" 0.1875" HOLE DIA 1/16" CORNER RADIUS AREA=0.20309 SQ IN		0.625"X 1.5" 0.375" HOLE DIA 1/16" CORNER RADIUS AREA=0.8237 SQ IN
TOTAL CONDUCTOR LENGTH/MAGNET	11069.52"	12389.52"	8804.88"
COIL PROTRUSION	4"	4"	6"
CU WEIGHT/MAGNET	722.84 PD	809.04 PD	22332.41 PD
TOTAL CU/WEIGHT	36.9 TONS	36.4 TONS	3.5 TONS
RESISTANCE/MAGNET (43 DEG C)	40.3 M OHM	45.1 M OHM	7.9 M OHM
CURRENT AT 10 T/M	250 A	230 A	1310 A
VOLTAGE AT 10 T/M	10.1 V	10.4 V	10.35 V
POWER/MAGNET	2.5 KW	2.4 KW	13.6 KW
TOTAL POWER/QUADS	0.258 MW	0.022 MW	0.041 MW
FULL CROSS SECTION (W X H)	30.5X29 SQ IN	30.5X29 SQ IN	54.75X51.75 SQ IN
LAMINATION THICKNESS	0.0598"	0.0598"	0.0598"
IRON WEIGHT	1.85 TONS	2.20 TONS	7.02 TONS
TOTAL IRON WEIGHT	188.6 TONS	19.8 TONS	21.1 TONS
COOLING WATER PRESSURE	19 PSI	26 PSI	3.1 PSI
WATER FLOW	0.8 GAL/MIN	1 GAL/MIN	2.2 GAL/MIN
NO. OF TURNS, TOTAL	4X33	4X33	4X21

MAXIMUM STRENGTH, B"L/B-RHO	0.22 M-2
BORE RADIUS	50 MM
EFFECTIVE LENGTH	0.2 M
MAXIMUM FIELD, B"	33 T/M2
AMPERE-TURNS	600 AT/POLE
CURRENT	119 A
TURNS	5 TURNS/POLE
CONDUCTOR SIZE	.3294" RECT/ 0.18" HOLE DIA/ AREA .07723 SQ IN
CURRENT DENSITY	1.55 KA/SQ IN
RESISTANCE ..	5 MICRO OHM/MAGNET
VOLTAGE DROP	0.65 V/MAGNET
THERMAL LOSS	77 W/MAGNET

KINETIC ENERGY	7.9 GEV
BETA	0.99438
GAMMA	9.4492
MOMENTUM (P)	8.81616 GEV/C
MAGNETIC RIGIDITY (B-RHO)	294.1 KG-M
BENDING FIELD (B)	16.84 KG
BENDING RADIUS (RHO)	17.46375 M
AVERAGE RADIUS (R)	75.4506 M
REVOLUTION PERIOD	1.590 MICROSEC
PACKING FACTOR (RHO/R)	23.146%
SUPERPERIODICITY	3
RF HARMONIC NUMBER (H)	84
FOCUSSING STRUCTURE	SEPARATED FUNCTIONS
NORMAL CELL STRUCTURE	NONE
HORIZONTAL BETATRON TUNE	6.61082
VERTICAL BETATRON TUNE	8.61144
TRANSITION ENERGY (GAMMA/T)	5.42986
$\text{ETA} = 1/(\text{GAMMA}/\text{T})^{**2} - 1/\text{GAMMA}^{**2}$	0.0227
NATURAL CHROMATICITY: HORIZONTAL	-8.47593
VERTICAL	-12.88242

DIPOLES	EFFECTIVE LENGTH	STRENGTH
B3	1.5240 M	16.839 KG
B7	3.0480 M	16.839 KG
B8, B9, B10	4.5720 M	16.839 KG
QUADRUPOLES	EFFECTIVE LENGTH	STRENGTH
Q1	0.64008 M	103.8087 KG/M
Q2	1.31166	-103.8087
Q3	0.70104	103.8087
Q4	0.45720	96.6333
Q5	0.82804	- 97.4126
Q6	0.70104	96.6333
Q7	0.70104	- 97.4126
Q8	0.45720	96.6333
Q9	0.45720	- 97.4126
Q10	0.45720	40.8765
Q11	0.87376	89.3989
Q12	0.77220	- 89.3989
Q13	0.77220	- 89.3989
Q14	0.64262	89.3989
SEXTUPOLES	EFFECTIVE LENGTH	STRENGTH
S7	0.3048 M	35.7175 KG/M2
S9	0.3048	-219.5244
S10	0.3048	134.7943
S12	0.3048	-170.5021
OCTUPOLES	EFFECTIVE LENGTH	STRENGTH
OC10	0.3048	-325.1426 KG/M3
OC12	0.3048	778.6057

LS	7.94650
LS*	7.84488
01	0.51241
02	0.96060
03	0.90420
0B3	6.42366
04	3.26100
05	7.33776
06	4.18716
07	0.30480
0S7	3.83584
0B7	0.50800
08	1.21920
0B8	0.50800
09	0.30480
0S9	0.60960
0B9	0.50800
010	0.50800
0B10	0.29190
0S10	0.29190
011	0.52102
012	0.21780
0S12	0.21780
013	0.49722

STRUCTURE OF HALF A SUPERPERIOD

STRING OF ELEMENTS FROM CENTER OF ZERO-DISPERSION STRAIGHT

SECTION TO CENTER OF LARGE-DISPERSION STRAIGHT SECTION

```
.CS =      LS  Q1  A1  O1  Q2  Q2  O2  Q3  Q3  O3  B3
          OB3 Q4  Q4  O4  Q5  Q5  O5  Q6  Q6  O6  Q7  Q7
          07  S7  OS7 B7  OB7 Q8  Q8  O8  B8  OB8 Q9  Q9
          09  S9  OS9 B9  OB9 Q10 Q10 O10 B10 OB10 S10 OS10
          Q11 Q11 O11 Q12 Q12 O12 S12 OS12 Q13 Q12 O13 Q14
          Q14 LS*
```

SUPERPERIOD STRUCTURE:

.CS + MIRROR REFLECTION OF .CS

	BETA-H	BETA-V	ETA-H
MAXIMA	33.23 M	31.04 M	8.949 M
B3	24.59	9.40	0.067
B7	17.82	16.01	-0.088
B8	15.96	18.80	0.891
B9	23.05	15.73	4.669
B10	31.97	9.12	8.065
Q1	16.01	19.98	0.001
Q2	14.59	30.32	0.001
Q3	26.32	12.60	0.001
Q4	14.31	8.13	0.645
Q5	2.95	28.90	0.680
Q6	29.99	2.98	1.915
Q7	6.60	31.04	0.634
Q8	14.57	8.35	-0.050
Q9	7.60	20.23	1.239
Q10	26.22	4.91	5.325
Q11	31.96	15.86	8.726
Q12	16.72	27.14	6.978
Q13	13.22	27.39	7.542
Q14	15.88	16.90	8.949
	BETA-H	BETA-V	ETA-H
(*) CENTER OF ZERO- DISPERSION LONG STRAIGHT SECTION	7.764 M	7.267 M	0.002 M
(**) CENTER OF LARGE DISPERSION LONG STRAIGHT SECTION	7.580	7.514	8.949
(*) TOTAL LENGTH = 15.8930 M	(**) TOTAL LENGTH = 15.6898 M		

(ALPHA*-H = ALPHA*-V = ETA' = 0)

EC.6

APERTURE REQUIREMENTS

11.43.15.

CHANGED 5/31/83
PRINTED 6/ 9/83

BETATRON ACCEPTANCE: HORIZONTAL 10 PI MM-MRAD

VERTICAL 10 PI MM-MRAD

MOMENTUM APERTURE: +- 1.25%

TYPE	B3	B7	B8	B9 & B10
NUMBER OF MAGNETS	6	6	6	12
EFFECTIVE LENGTH (M)	1.5240	3.0480	4.5720	4.5720
BENDING FIELD (KG)	16.839	16.839	16.839	16.839
SAGITTA (CM)	1.66	6.65	14.96	14.96
DIPOLE GEOMETRY	CURVED WITH PARALLEL EDGES			
BENDING ANGLE (MRAD)	87.266	174.533	261.799	261.799
BENDING RADIUS (M)	17.464	17.464	17.464	17.464
IRON LENGTH (IN)	57.43	117.30	176.94	176.94
GAP HEIGHT (IN)	2.36	2.36	2.36	2.36
GAP WIDTH (IN)	7.68	7.68	7.68	11.22
COIL END EXTENSION (IN)	2.55	2.55	2.55	2.55
NO. OF TURNS	72	72	72	72
CURRENT EXCITATION (AMPS)	1150	1150	1150	1150
POWER / MAGNET (KW)	10.879	18.309	25.737	26.471

TYPE	NUMBER	EFFECTIVE LENGTH	STRENGTH
Q1	6	0.64008 M	103.8087 KG/M
Q2	6	1.31166	-103.8087
Q3	6	0.7104	103.8087
Q4	6	0.45720	96.6333
Q5	6	0.82804	-97.4126
Q6	6	0.70104	96.6333
Q7	6	0.70104	-97.4126
Q8	6	0.45720	96.6333
Q9	6	0.45720	-97.4126
Q10	6	0.45720	40.8765
Q11	6	0.87376	89.3989
Q12	6	0.77220	-89.3989
Q13	6	0.77220	-89.3989
Q14	6	0.64262	89.3989

OTHER PARAMETERS:

TYPE	Q1 - Q9	Q10	Q11 - Q14
POLE TIP RADIUS	44.5 MM	85 MM	85 MM
NO. OF TURNS	132	40	84
POLE TIP FIELD (MAX)	4.5 KG	2.7 KG	7.7 KG
CURRENT EXCITATION (AMPS)	266	1150	1150
POWER / MAGNET (KW)	2.20-4.48	3.51	8.98-10.79

TYPE	NUMBER	EFFECTIVE LENGTH	STRENGTH
S7	6	0.3048	35.7175 KKG/M2
S9	6	0.3048	-219.5244
S10	6	0.3048	134.7943
S12	6	0.3048	-170.5021

OTHER PARAMETERS:

TYPE	S7,S9	S10,S12
POLE TIP RADIUS	?	?
NO OF TURNS	?	?
POLE TIP FIELD	?	?
CURRENT EXCITATION (AMPS)	?	?
POWER / MAGNET (KW)	?	?

TYPE	NUMBER	EFFECTIVE LENGTH	STRENGTH
OC10	6	0.3048	-325.1426 KG/M3
OC12	6	0.3048	778.6057

OTHER PARAMETERS:

POLE TIP RADIUS ?

NO OF TURNS ?

POLE TIP FIELD ?

CURRENT EXCITATION (AMPS) ?

POWER / MAGNET (KW) ?

TYPE	NUMBER	EFFECTIVE LENGTH	STRENGTH
S7	6	8.0 "	53.57 KG/M2
S9	6	8.0	-330.1
S10	6	8.0	202.7
S12	6	8.0	-256.3

OTHER PARAMETERS:

TYPE	S7,S9
POLE TIP RADIUS	2.8125 "
NO OF TURNS	6 PER POLE
POLE TIP FIELD (KG)	0.14, 0.84
CURRENT EXCITATION (AMPS)	42.5, 262
POWER / MAGNET (KW)	.061, 0.375

TYPE	NUMBER	EFFECTIVE LENGTH	STRENGTH
OC10	6	8.0	-487.9 KG/M3
OC12	6	8.0	406.4