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BNL MAD Program Notes: Survey Matching

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Collider Accelerator Department

Brookhaven National Laboratory

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Accelerator Division
Technical Note

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1. Summary

The set of position and direction calculations produced by the MAD Survey command has been added to the BNL MAD parameter matching ensemble. These simple procedures should help with designs of beam lines such as those between machines, where both lattice geometry and beam optics criteria may be involved. In a typical application, magnet positions and bend angles needed to guide beams into a fixed space point at a given angle might be computed. For example, in a possible rebuild of the BTA, major steering early in the line is modified in various ways to reduce dispersion. Bend angles and spacing among the bend magnets needs to be arranged so the beam is properly directed into the AGS entrance section, perhaps by satisfying a particular set of coordinates at the end of DH5.

Changes in the input language for the BNL Fast Match section are described. Where there is overlap with somewhat distantly related CERN v.8 features, similar command and attribute names have been used. An example bend angle tuning run is given for a BTA trial lattice with four early bends and 19 quads. All program changes are in the MatchF.B source file.

2. New FSurfit Command

The six spatial and direction angle coordinates of the start of a periodic beam line are entered with the **FSurfit** command. The angle definitions quoted are copied from the regular MAD User's Reference Manual. This command is not needed if all starting values are zero. Coordinate defaults are set to 0.m, direction defaults to 0. rad. In future applications, features may be added to use information on an existing reference Survey file for constraint or other values.

Svx	The starting X coordinate in meters, in the appropriate survey (global) system. Axes are the same as for the lattice optics, with the starting Z nominally in the direction of the beam.
Svy, Svz	The starting Y and Z survey coordinates in meters.
Svtheta	Azimuth angle in radians, between the global X and Z axes, about the global Y axis.

Svpsi — Tilt (roll) angle in radians about the local s axis. "The angle between the intersection of the local (x, y) and global (Z, X) planes and the local x axis. A positive *Psi* forms a right hand screw with the s axis."

Svphi — Elevation (dip) angle in radians. "The angle between the reference orbit and its projection onto the (Z, X) plane. If only horizontal bends are involved, the reference orbit remains in the (Z, X) plane. For this case, *Phi* is always 0."

Svclen — Intended as a starting element length sum value, but currently set to zero.

Svslen — Intended as a starting arc length sum value, but currently set to zero.

File(8) — The name of a Survey formatted file, including any path modifiers, produced by a **Survey** command with the *Tape* attribute used. *File* is string form in quotes with up to 64 characters. This file is intended to be a source of survey information about some reference line which could be involved in the survey matching. For the present, this feature is not used. To be useful, it will need some rather complicated coding to deal with trial lattices that may have somewhat different configurations and element names than the reference one.

If the **FMatch** *Line* attribute is given, the six initial survey coordinates describe the spatial origin of the initial line as named on the attribute. The results of survey tracking over the initial line are fed as inputs into the (Use) line being matched. Otherwise the *Svx,* etc group describes the start of the line being matched, noted on the **USE** command.

3. The FSConstraint Command

A new command, **FSConstraint,** has been introduced to describe survey coordinate constraints. As for other MAD constraints, the constrained variables may be noted by the usual =, > or < operators, indicating equality or limits such as an acceptance window. This closely resembles the ordinary FConstraint command, with the survey coordinates replacing the orbit functions. Only those survey variables for which data are given are constrained. Weights are defaulted from the dictionary or internal tables if they are not given.

Place — A MAD place group describing a position, or range of positions along the orbit for which the constraints are to be applied.

Svx — A constraint form for the value or range of values which are to be satisfied at each position included within the *Place* attribute. This and the following five attributes refer to the same spatial coordinates or directions as noted for the **FSurfit** command above.

Svy, Svz

Svtheta, Svpsi, Svphi

Svclen — The total length in meters over individual elements of the lattice section. This is meaningful only at the end of a specific lattice element, and will give rather silly results if applied to a line segment.

Svslen — The total path length in meters of the beam through all elements of the lattice section. This too is meaningful only at the end of a specific lattice element.

Others(2) — Intended for names of additional survey related variables. MAD variable name format, of element name, attribute name, and any needed indices.

Othercs(2) — Intended for constraint form of values of the *Others* named variables.

Weights(10) — Weights to be applied to each of the above constraints. If a constraint value is given without the corresponding weight, a default will be supplied from the dictionary, or failing this, from an internal table. Weights are provided separately here, as the survey nominal tolerances are usually of the order of .001m, which differ markedly from the familiar optical defaults of 1., etc.

Optical tracking and the usual Match summary listings are not printed if only survey constraints are given.

4. Program Changes

The changes needed for the survey matching blend easily into the existing BNL MAD Fast Match object and tracking codes, involving perhaps a thousand or so lines of new or modified code, including the usual nervous cleanup. As C++ isn't involved, this is only a day's work to edit and get to run.

A Matsurfit_F section has been added to accept the initial survey coordinates given on **FSurfit** input statements. This section deals with the FSurfit command, and its corresponding data base object. Minor changes in the Cell_F and Match_F sections clear flags for the survey matching, and in Matini_F reset the initial survey values vector.

A ConstrS_F section has been added to process FSConstraint statements, and handle the corresponding class of survey constraint objects during the matching operations. It is mainly an edited copy of the ordinary Constr_F lattice function constraint section. Survey tracking is done only if at least one survey constraint is given.

All sections which initialize and carry out lattice tracking have been modified to include survey tracking when one or more survey constraints have been given. These include Matbgn_F, Matend_F, Matin_F, Penbgn_F, and Penlty_F routines. A new routine Matsurvey_F has been added to do survey tracking for Penbgn_F when initial survey values are to be taken from a previously computed line. The current library of constraints, and the Migrad_F and Simplx_F search routines have not had to be changed.

5. Example

A sample set of survey matching commands, and the corresponding survey match run results are given at the end. The matching group setup is basically the same as for ordinary optics matching. In this BTA case, a trial line has been substituted in the region between quad QH4 near the Booster and bend DH5 near the AGS. The initial bending has been split into four equally spaced identical bends, separated by alternating H and V quads. The bending angle is adjusted to bring the line into the center of bend DH5 near the entrance to the AGS. A second run, not shown here, then adjusts the DH5 bend in

similar fashion.

The use of FConstraint and FVary lists with the FMatch command is included in this example. (Xmenu lists) In a problem such as the BTA which has many parameters to be matched to the numerous constraints during each of a number of trials, the editing situation soon gets out of hand as these command groups are moved in and out of the FMatch .... Fendmatch clusters. Instead libraries of stored FConstraint and FVary commands are maintained, with each command identified by a unique name. The set of constraints and variables to be currently applied is then simply noted by including the names in lists. As the various trials progress, selected lists of names can be used to distinguish among trials, and hopefully some sense of order is obtained. The collections of commands also serve as history files, from which individual members can be recalled. Under this style, editing of constraint and parameter sets is reduced to shuffling names of commands in lists.

6. Comments

A somewhat different approach to survey matching has been given by H. Grote in *MAD Survey Matching* , SL Note 95-56(AP) (CERN). July, 1995 It takes its comparison coordinates from a previously computed Survey file as reference, and expresses its constraints in terms of distances from that reference survey. It is oriented towards the problem of positioning a second ring around a first, with emphasis on maintaining separations and path lengths within restricted spaces. In principle it could be used here for BTA trial lattices with the present BTA survey as reference, constraining bend angles and spacings to match an existing entrance constraint condition to the AGS. Sadly, this involves time consuming mixing among program versions for a problem that has already involved major tailoring of our multi parameter search routines to deal better with local conditions. For now it has seemed easier to embed a few simple survey match features into our visually oriented BNL MAD than to jump between programs to get graphics.

The initial condition command does the same thing for the two versions, so we have used a minor variant of the CERN keyword definition, Surfit. The constraints are expressed rather differently, so we have used a keyword definition based on the ordinary Constraint command that it resembles.

Documents

Unix Typesetter Format - troff / psroff Files.

Host	**rapt.ags.bnl.gov**
This Report	/usr/disc2/jn/Docum+/Fmatch.man2
FMatch	/usr/disc2/jn/Docum+/Fmatch.man

To Print from rapt: (To Room 218 AGS 2nd Floor)

```
alias it.    'cat * | psroff -t -ms > ppp; lp ppp'
     it.     Manual Name
```

```
!           Example Command File for Survey Matching of BTA.
!*****************************************************************
!     Nominal Older Entry Set from Booster.    July 1.96
     BETAX0_1  Param  = 13.101 ;       ALFAX0_1  Param  =  1.851
     BETAY0_1  Param  =  3.87  ;       ALFAY0_1  Param  = -.596
     DX_0_1    Param  =  2.85  ;       DPX_0_1   Param  =  -.427
     Pdelta    Param  =  0.
!*****************************************************************
  !    Match Section for JBTA - Trail Lattice.   Vary Four Bend Angles.
  !     Survey Constraints - "Library"
     Store
      !     Center of DH5 - Original Survey.
       SV_DH5a   FSconst   Place = DH5a,   Svx = - 17.309210
       SV_DRL20  FSconst   Place = DRL20b, Svx = - 20.124342,          &
                                           Svtheta = -.462420
     Endstore
  !    List of Constraints, Selected from "Constraint Library".
     SV_list5   Xmenu = SV_DH5a

  !    Vary Commands - "Library"
     Store
       VS_B2adj   Fvary,   B2adjust,       Step  =  .002,              &
                           Lower = 1.02,   Upper = 1.081
       VS_B5adj   Fvary,   B5adjust,       Step  =  .005,              &
                           Lower = 1.10,   Upper = 1.201
     Endstore
  !    List of Vary Commands, Selected from "Vary Library".
     VS_list5   Xmenu = VS_B2adj
!*****************************************************************
  !    Match Command Library.
    Store
      FMI       Fmigrad,  Calls =  2000, TOLERANC = 1.E-8
      FSI       Fsimplex, Calls =   500, TOLERANC = 1.E-13,  Revised
      FMA_5S    Fmatch,                  deltap  = pdelta,     Second,   &
                Varlist = VS_list5,      Conlist = SV_list5,             &
                BETX    = Betax0_1,      ALFX    = Alfax0_1,             &
                BETY    = Betay0_1,      ALFY    = Alfay0_1,             &
                DX      = Dx_0_1,        DPX     = Dpx_0_1
      FTW.5     Ftwiss,                  deltap  = pdelta,               &
                BETX    = Betax0_1,      ALFX    = Alfax0_1,             &
                BETY    = Betay0_1,      ALFY    = Alfay0_1,             &
                DX      = Dx_0_1,        DPX     = Dpx_0_1
    Endstore
!*****************************************************************
!   Use AGS Landscape Printing Format - 160 Columns.
      Setopts, Wide
      Use   JBTA
!   Fmatch Group
      FMA_5s
      FSurfit   Svx = 0.,   Svy = 0.,     Svz = 0.
      FSI
      Fendmatch  -Verbose,  File = "Matchlist.bta"

!   Ftwiss Run with Match Results.
      Print JBTA
      Ftw.5

      Return

      STOP
```

!! Matching on BTA Trial Lattice J. Adjust Bend Angle.

... BEGIN INSERTION MATCHING MODE.

Start of Simplex 2 Minimization, Tolerance = 1.00E-13

PENALTY FCT.	CALL	TIME	E.D.M.	PARAMETER NAME	PAR. VALUE	PAR. ERROR
8.366891E+05	1	0.000	1.000E+25	B2ADJUST	1.000000E+00	2.000000E-03

PENALTY FCT.	CALL	TIME	E.D.M.	PARAMETER NAME	PAR. VALUE	PAR. ERROR
1.050875E+04	6	0.000	2.573E+05	B2ADJUST	1.041006E+00	2.100600E-02

Simplex2_F: Minimization Has Converged

PENALTY FCT.	CALL	TIME	E.D.M.	PARAMETER NAME	PAR. VALUE	PAR. ERROR
1.601990E-15	71	2.000	1.554E-15	B2ADJUST	1.046213E+00	4.890754E-12

Region about Simplex Fit.

	Original Values,	Fitted Values.	Increment /	Value /	Penalty						
1	B2ADJUST	0.104621E+01	0.100000E+01								
-0.200000E-02	-0.100000E-02	-0.600000E-03	-0.400000E-03	-0.200000E-03	0.000000E+00	0.200000E-03	0.400000E-03	0.600000E-03	0.100000E-02	0.200000E-02	
0.104421E+01	0.104521E+01	0.104561E+01	0.104581E+01	0.104601E+01	0.104621E+01	0.104641E+01	0.104661E+01	0.104681E+01	0.104721E+01	0.104821E+01	
0.154877E+04	0.387089E+03	0.139337E+03	0.619242E+02	0.154802E+02	0.160199E-14	0.154785E+02	0.619108E+02	0.139292E+03	0.386879E+03	0.154710E+04	

... End of "Simplex_F" Command, Elapsed Cpu Time = 2.4433 0.0283 Seconds

MATCHING SUMMARY FOR BEAM LINE "JBTA ", RANGE = "#S / #E"

POS. NO.	ELEMENT NAME	OCC. NO.	DIST M	CONDITION TYPE	QUANTITY NAME	WEIGHT	ACTUAL VALUE	MINIMUM VALUE	MAXIMUM VALUE	PENALTY CONTRIBUTION
75	DH5A	1	57.120	Survey Constraints						
					SvX	1.000000E+03	-1.730921E+01	-1.730921E+01	0.000000E+00	1.601990E-15

Summary of Survey Matching

	E L E M E N T	S E Q U E N C E		I	P O S I T I O N S			I	A N G L E S				
POS.		SUM(L)	ARC	I	X	Y	Z	I	THETA	PHI	PSI	I ELEMENT	LENGTH STRENGTH
NO.	NAME	M	M	I	M	M	M	I	RAD	RAD	RAD	I	M
0	Begin	0.000000	0.000000		0.000000	0.000000	0.000000		0.000000	0.000000	0.000000		
91	End	65.032629	65.033342		-20.190216	0.000000	59.958642		-0.473823	0.000000	0.000000		

..... Last Value of the Penalty Function: 1.601990E-15

..... End Matching Mode.

LINEAR LATTICE PARAMETERS FOR BEAM LINE: "JBTA ", RANGE = "#S / #E"
DELTA(P)/P = 0.000000 symm = F PAGE 1

POS. NO.	ELEMENT NAME	SEQUENCE OCC. NO.	I DIST [M] I	HORIZONTAL BETAX [M]	ALFAX [1]	MUX [2PI]	X(CO) [MM]	PX(CO) [.001]	DX [M]	DPX [1] I	VERTICAL BETAY [M]	ALFAY [1]	MUY [2PI]	Y(CO) [MM]	PY(CO) [.001]	DY [M]	DPY [1]	ELEMENT	LENGTH	STRENGTH
BEGIN	JBTA	1	0.000	13.101	1.851	0.000	0.000	0.000	2.850	-0.427	3.870	-0.596	0.000	0.000	0.000	0.000	0.000			
BEGIN	L0	1	0.000	13.101	1.851	0.000	0.000	0.000	2.850	-0.427	3.870	-0.596	0.000	0.000	0.000	0.000	0.000			
1	MQHF6	1	0.000	13.101	1.851	0.000	0.000	0.000	2.850	-0.427	3.870	-0.596	0.000	0.000	0.000	0.000	0.000	MARKER	0.00000	0.0000
2	DRQF6	1	0.236	12.246	1.771	0.003	0.000	0.000	2.749	-0.427	4.171	-0.679	0.009	0.000	0.000	0.000	0.000	DRIFT	0.23610	0.0000
3	DHF6A	1	1.486	8.297	1.348	0.023	0.000	0.000	2.160	-0.507	6.415	-1.090	0.048	0.000	0.000	0.000	0.000	SBEND	1.25000	-0.0715
4	DRF6A1	1	1.506	8.244	1.341	0.023	0.000	0.000	2.150	-0.507	6.458	-1.097	0.049	0.000	0.000	0.000	0.000	DRIFT	0.01975	0.0000
5	DHF6T	1	1.506	8.244	1.341	0.023	0.000	0.000	2.150	-0.507	6.458	-1.097	0.049	0.000	0.000	0.000	0.000	HKICK	0.00000	0.0000
6	DRF6A2	1	1.526	8.191	1.335	0.023	0.000	0.000	2.140	-0.507	6.501	-1.104	0.049	0.000	0.000	0.000	0.000	DRIFT	0.01975	0.0000
7	DHF6B	1	2.853	5.251	0.885	0.056	0.000	0.000	1.425	-0.572	9.999	-1.531	0.075	0.000	0.000	0.000	0.000	SBEND	1.32690	-0.0594
8	DRF6B	1	3.259	4.588	0.747	0.069	0.000	0.000	1.193	-0.572	11.299	-1.666	0.082	0.000	0.000	0.000	0.000	DRIFT	0.40640	0.0000
END	L0	1	3.259	4.588	0.747	0.069	0.000	0.000	1.193	-0.572	11.299	-1.666	0.082	0.000	0.000	0.000	0.000			
BEGIN	L1	1	3.259	4.588	0.747	0.069	0.000	0.000	1.193	-0.572	11.299	-1.666	0.082	0.000	0.000	0.000	0.000			
9	PUEH001	1	3.259	4.588	0.747	0.069	0.000	0.000	1.193	-0.572	11.299	-1.666	0.082	0.000	0.000	0.000	0.000	MONITOR	0.00000	0.0000
10	DR001	1	4.344	3.368	0.378	0.114	0.000	0.000	0.573	-0.572	15.308	-2.029	0.095	0.000	0.000	0.000	0.000	DRIFT	1.08490	0.0000
11	MW006	1	4.344	3.368	0.378	0.114	0.000	0.000	0.573	-0.572	15.308	-2.029	0.095	0.000	0.000	0.000	0.000	MARKER	0.00000	0.0000
12	DR006	1	4.776	3.104	0.231	0.135	0.000	0.000	0.326	-0.572	17.126	-2.174	0.099	0.000	0.000	0.000	0.000	DRIFT	0.43260	0.0000
13	DV007	1	5.005	3.016	0.154	0.147	0.000	0.000	0.195	-0.572	18.138	-2.250	0.101	0.000	0.000	0.000	0.000	VKICK	0.22860	0.0000
14	DR007	1	5.166	2.975	0.099	0.155	0.000	0.000	0.103	-0.572	18.869	-2.304	0.102	0.000	0.000	0.000	0.000	DRIFT	0.16060	0.0000
15	QV1	1	5.724	3.634	-1.361	0.184	0.000	0.000	-0.216	-0.592	17.486	4.601	0.107	0.000	0.000	0.000	0.000	QUADRUPO	0.55880	-0.6754
16	DRQ1	1	6.128	4.859	-1.677	0.199	0.000	0.000	-0.455	-0.592	13.982	4.090	0.111	0.000	0.000	0.000	0.000	DRIFT	0.40315	0.0000
17	DH1	1	6.661	6.870	-2.095	0.214	0.000	0.000	-0.760	-0.553	9.965	3.438	0.118	0.000	0.000	0.000	0.000	RBEND	0.53330	0.0364
END	L1	1	6.661	6.870	-2.095	0.214	0.000	0.000	-0.760	-0.553	9.965	3.438	0.118	0.000	0.000	0.000	0.000			
BEGIN	JJ2	1	6.661	6.870	-2.095	0.214	0.000	0.000	-0.760	-0.553	9.965	3.438	0.118	0.000	0.000	0.000	0.000			
18	DRD1	1	7.040	8.573	-2.393	0.221	0.000	0.000	-0.970	-0.553	7.541	2.950	0.125	0.000	0.000	0.000	0.000	DRIFT	0.37935	0.0000
19	QH2A	1	7.599	8.731	2.138	0.231	0.000	0.000	-1.127	0.004	6.414	-0.742	0.139	0.000	0.000	0.000	0.000	QUADRUPO	0.55880	0.9271
20	DRQ2A	1	7.715	8.245	2.064	0.233	0.000	0.000	-1.127	0.004	6.590	-0.770	0.142	0.000	0.000	0.000	0.000	DRIFT	0.11580	0.0000
21	QH2B	1	8.274	4.374	4.182	0.248	0.000	0.000	-0.965	0.559	9.808	-5.535	0.153	0.000	0.000	0.000	0.000	QUADRUPO	0.55880	0.9271
22	DRQ2B	1	8.734	1.422	2.238	0.277	0.000	0.000	-0.708	0.559	15.582	-7.019	0.159	0.000	0.000	0.000	0.000	DRIFT	0.45990	0.0000
23	XF019	1	8.734	1.422	2.238	0.277	0.000	0.000	-0.708	0.559	15.582	-7.019	0.159	0.000	0.000	0.000	0.000	MARKER	0.00000	0.0000
24	DR019A	1	9.324	0.252	-0.256	0.500	0.000	0.000	-0.378	0.559	24.990	-8.923	0.164	0.000	0.000	0.000	0.000	DRIFT	0.59020	0.0000
25	QV3	1	9.883	2.231	-3.734	0.646	0.000	0.000	-0.121	0.391	24.909	9.049	0.167	0.000	0.000	0.000	0.000	QUADRUPO	0.55880	-1.2484
26	DRQ3A	1	9.989	3.099	-4.445	0.653	0.000	0.000	-0.079	0.391	23.026	8.696	0.168	0.000	0.000	0.000	0.000	DRIFT	0.10610	0.0000
27	FOIL024	1	9.989	3.099	-4.445	0.653	0.000	0.000	-0.079	0.391	23.026	8.696	0.168	0.000	0.000	0.000	0.000	MARKER	0.00000	0.0000
28	DR024	1	10.933	17.459	-10.767	0.673	0.000	0.000	0.290	0.391	9.573	5.555	0.178	0.000	0.000	0.000	0.000	DRIFT	0.94400	0.0000
END	JJ2	1	10.933	17.459	-10.767	0.673	0.000	0.000	0.290	0.391	9.573	5.555	0.178	0.000	0.000	0.000	0.000			
BEGIN	JJ3	1	10.933	17.459	-10.767	0.673	0.000	0.000	0.290	0.391	9.573	5.555	0.178	0.000	0.000	0.000	0.000			
29	QH4	1	11.491	20.328	6.512	0.677	0.000	0.000	0.422	0.061	7.913	-2.108	0.189	0.000	0.000	0.000	0.000	QUADRUPO	0.55880	1.5901
30	JDQH4	1	12.091	13.282	5.231	0.683	0.000	0.000	0.458	0.061	10.690	-2.520	0.200	0.000	0.000	0.000	0.000	DRIFT	0.60000	0.0000
31	NBH2A	1	13.301	3.739	2.664	0.711	0.000	0.000	0.626	0.217	17.592	-3.143	0.214	0.000	0.000	0.000	0.000	SBEND	1.21000	0.1442
32	JDH2A	1	13.901	1.321	1.365	0.754	0.000	0.000	0.757	0.217	21.587	-3.514	0.219	0.000	0.000	0.000	0.000	DRIFT	0.60000	0.0000
33	NQV4	1	14.400	0.593	0.168	0.852	0.000	0.000	0.924	0.463	21.878	2.960	0.222	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	-0.5925
34	JDQV4	1	15.000	1.016	-0.873	0.993	0.000	0.000	1.202	0.463	18.487	2.692	0.227	0.000	0.000	0.000	0.000	DRIFT	0.60000	0.0000
35	NBH2B	1	16.210	5.633	-2.947	1.077	0.000	0.000	1.852	0.615	12.403	2.300	0.240	0.000	0.000	0.000	0.000	SBEND	1.21000	0.1442
36	JDH2B	1	16.810	9.788	-3.979	1.090	0.000	0.000	2.221	0.615	9.825	1.996	0.248	0.000	0.000	0.000	0.000	DRIFT	0.60000	0.0000
37	NQH5	1	17.308	11.580	0.654	1.097	0.000	0.000	2.275	-0.402	10.005	-2.382	0.257	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	0.8909
38	JDQH5	1	17.908	10.840	0.580	1.105	0.000	0.000	2.034	-0.402	13.103	-2.782	0.265	0.000	0.000	0.000	0.000	DRIFT	0.60000	0.0000
39	NBH3A	1	19.118	9.573	0.468	1.124	0.000	0.000	1.639	-0.251	20.570	-3.344	0.277	0.000	0.000	0.000	0.000	SBEND	1.21000	0.1442
40	JDH3A	1	19.718	9.057	0.392	1.135	0.000	0.000	1.489	-0.251	24.796	-3.699	0.281	0.000	0.000	0.000	0.000	DRIFT	0.60000	0.0000

LINEAR LATTICE PARAMETERS FOR BEAM LINE: "JBTA ", RANGE = "#S / #E"
DELTA(P)/P = 0.000000 symm = F PAGE 2

ELEMENT SEQUENCE POS. NO.	ELEMENT NAME	OCC. NO.	DIST [M]	I	HORIZONTAL BETAX [M]	ALFAX [1]	MUX [2PI]	X(CO) [MM]	PX(CO) [.001]	DX [M]	DPX [1]	I	VERTICAL BETAY [M]	ALFAY [1]	MUY [2PI]	Y(CO) [MM]	PY(CO) [.001]	DY [M]	DPY [1]	ELEMENT	LENGTH	STRENGTH
41	NQV5	1	20.217		9.981	-2.330	1.143	0.000	0.000	1.465	0.156		25.002	3.305	0.284	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	-0.5594
42	JDQV5	1	20.817		13.010	-2.717	1.151	0.000	0.000	1.559	0.156		21.208	3.019	0.288	0.000	0.000	0.000	0.000	DRIFT	0.60000	0.0000
43	NBH3B	1	22.027		20.424	-3.417	1.163	0.000	0.000	1.839	0.308		14.343	2.613	0.299	0.000	0.000	0.000	0.000	SBEND	1.21000	0.1442
44	JDH3B	1	22.627		24.748	-3.789	1.167	0.000	0.000	2.024	0.308		11.403	2.286	0.307	0.000	0.000	0.000	0.000	DRIFT	0.60000	0.0000
45	NQH6	1	23.125		24.986	3.336	1.171	0.000	0.000	2.032	-0.275		10.737	-0.887	0.314	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	0.5696
END	JJ3	1	23.125		24.986	3.336	1.171	0.000	0.000	2.032	-0.275		10.737	-0.887	0.314	0.000	0.000	0.000	0.000			
BEGIN	JJ4	1	23.125		24.986	3.336	1.171	0.000	0.000	2.032	-0.275		10.737	-0.887	0.314	0.000	0.000	0.000	0.000			
46	JDQH6	1	26.036		9.680	1.923	1.201	0.000	0.000	1.232	-0.275		17.311	-1.372	0.348	0.000	0.000	0.000	0.000	DRIFT	2.91045	0.0000
47	NQV7	1	26.534		8.191	1.099	1.210	0.000	0.000	1.117	-0.190		18.071	-0.134	0.353	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	-0.1449
48	JDQV7	1	29.445		4.076	0.315	1.294	0.000	0.000	0.563	-0.190		19.330	-0.298	0.378	0.000	0.000	0.000	0.000	DRIFT	2.91045	0.0000
49	NQH8	1	29.943		3.821	0.196	1.314	0.000	0.000	0.468	-0.192		19.683	-0.410	0.382	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	0.0085
50	JDQH8	1	32.854		4.981	-0.595	1.430	0.000	0.000	-0.093	-0.192		22.571	-0.583	0.404	0.000	0.000	0.000	0.000	DRIFT	2.91045	0.0000
51	NQV8	1	33.352		6.134	-1.786	1.445	0.000	0.000	-0.194	-0.218		21.189	3.271	0.407	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	-0.3568
52	JDQH8A	1	34.541		11.345	-2.598	1.467	0.000	0.000	-0.453	-0.218		14.193	2.615	0.418	0.000	0.000	0.000	0.000	DRIFT	1.18858	0.0000
53	DH4	1	35.074		14.310	-2.963	1.474	0.000	0.000	-0.564	-0.199		11.558	2.327	0.425	0.000	0.000	0.000	0.000	RBEND	0.53330	0.0171
54	JDQH8B	1	36.263		22.318	-3.775	1.485	0.000	0.000	-0.801	-0.199		6.811	1.667	0.446	0.000	0.000	0.000	0.000	DRIFT	1.18858	0.0000
END	JJ4	1	36.263		22.318	-3.775	1.485	0.000	0.000	-0.801	-0.199		6.811	1.667	0.446	0.000	0.000	0.000	0.000			
BEGIN	JJ5A	1	36.263		22.318	-3.775	1.485	0.000	0.000	-0.801	-0.199		6.811	1.667	0.446	0.000	0.000	0.000	0.000			
55	NQH9	1	36.761		22.536	3.360	1.488	0.000	0.000	-0.835	0.062		6.241	-0.465	0.459	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	0.6318
56	JDQH9	1	39.672		7.596	1.773	1.524	0.000	0.000	-0.655	0.062		10.596	-1.032	0.517	0.000	0.000	0.000	0.000	DRIFT	2.91045	0.0000
57	NQV9	1	40.170		6.455	0.574	1.535	0.000	0.000	-0.648	-0.034		10.858	0.519	0.524	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	-0.2974
58	JDQV9	1	43.081		4.860	-0.026	1.622	0.000	0.000	-0.747	-0.034		8.826	0.179	0.572	0.000	0.000	0.000	0.000	DRIFT	2.91045	0.0000
59	NQH10	1	43.579		4.614	0.509	1.639	0.000	0.000	-0.738	0.067		9.279	-1.108	0.581	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	0.2718
60	JDQH10	1	46.490		3.963	-0.285	1.758	0.000	0.000	-0.543	0.067		17.760	-1.806	0.618	0.000	0.000	0.000	0.000	DRIFT	2.91045	0.0000
61	NQV11	1	46.988		4.997	-1.895	1.776	0.000	0.000	-0.551	-0.101		16.819	3.595	0.622	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	-0.6248
62	JDQV11	1	49.899		23.815	-4.570	1.819	0.000	0.000	-0.845	-0.101		2.905	1.185	0.690	0.000	0.000	0.000	0.000	DRIFT	2.91045	0.0000
63	NQH12	1	50.397		24.969	2.365	1.822	0.000	0.000	-0.835	0.140		2.254	0.182	0.722	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	0.5675
64	JDQH12	1	53.307		13.439	1.596	1.848	0.000	0.000	-0.429	0.140		5.078	-1.152	0.887	0.000	0.000	0.000	0.000	DRIFT	2.91045	0.0000
END	JJ5A	1	53.307		13.439	1.596	1.848	0.000	0.000	-0.429	0.140		5.078	-1.152	0.887	0.000	0.000	0.000	0.000			
BEGIN	JJ5B	1	53.307		13.439	1.596	1.848	0.000	0.000	-0.429	0.140		5.078	-1.152	0.887	0.000	0.000	0.000	0.000			
65	QV13	1	53.806		13.905	-2.577	1.854	0.000	0.000	-0.391	0.016		5.487	0.375	0.902	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	-0.6134
66	DRQ13	1	54.403		17.177	-2.905	1.860	0.000	0.000	-0.382	0.016		5.113	0.251	0.920	0.000	0.000	0.000	0.000	DRIFT	0.59695	0.0000
67	MW166	1	54.403		17.177	-2.905	1.860	0.000	0.000	-0.382	0.016		5.113	0.251	0.920	0.000	0.000	0.000	0.000	MARKER	0.00000	0.0000
68	DR166	1	54.833		19.780	-3.141	1.864	0.000	0.000	-0.375	0.016		4.935	0.162	0.934	0.000	0.000	0.000	0.000	DRIFT	0.43050	0.0000
69	DV168	1	55.077		21.344	-3.275	1.865	0.000	0.000	-0.371	0.016		4.869	0.111	0.941	0.000	0.000	0.000	0.000	VKICK	0.24380	0.0000
70	DR168	1	55.374		23.334	-3.438	1.868	0.000	0.000	-0.366	0.016		4.821	0.049	0.951	0.000	0.000	0.000	0.000	DRIFT	0.29640	0.0000
71	PUEH170	1	55.374		23.334	-3.438	1.868	0.000	0.000	-0.366	0.016		4.821	0.049	0.951	0.000	0.000	0.000	0.000	MONITOR	0.00000	0.0000
72	DR170	1	55.492		24.156	-3.503	1.868	0.000	0.000	-0.364	0.016		4.812	0.025	0.955	0.000	0.000	0.000	0.000	DRIFT	0.11835	0.0000
73	QH14	1	55.990		24.643	2.566	1.872	0.000	0.000	-0.335	0.103		5.457	-1.371	0.971	0.000	0.000	0.000	0.000	QUADRUPO	0.49850	0.4959
74	DRQ14	1	56.497		22.122	2.410	1.875	0.000	0.000	-0.282	0.103		6.983	-1.639	0.984	0.000	0.000	0.000	0.000	DRIFT	0.50675	0.0000
75	DH5A	1	57.120		19.242	2.219	1.880	0.000	0.000	-0.245	0.018		9.181	-1.880	0.996	0.000	0.000	0.000	0.000	RBEND	0.62280	-0.0774
76	DH5B	1	57.743		16.600	2.027	1.885	0.000	0.000	-0.260	-0.067		11.652	-2.076	1.006	0.000	0.000	0.000	0.000	RBEND	0.62280	-0.0774
END	JJ5B	1	57.743		16.600	2.027	1.885	0.000	0.000	-0.260	-0.067		11.652	-2.076	1.006	0.000	0.000	0.000	0.000			
BEGIN	L6	1	57.743		16.600	2.027	1.885	0.000	0.000	-0.260	-0.067		11.652	-2.076	1.006	0.000	0.000	0.000	0.000			
77	DRD5	1	58.194		14.832	1.888	1.890	0.000	0.000	-0.290	-0.067		13.620	-2.282	1.012	0.000	0.000	0.000	0.000	DRIFT	0.45160	0.0000
78	DV181	1	58.438		13.930	1.813	1.893	0.000	0.000	-0.306	-0.067		14.759	-2.393	1.014	0.000	0.000	0.000	0.000	VKICK	0.24380	0.0000
79	DR181	1	58.818		12.597	1.696	1.897	0.000	0.000	-0.332	-0.067		16.642	-2.566	1.018	0.000	0.000	0.000	0.000	DRIFT	0.37980	0.0000
80	XF183	1	58.818		12.597	1.696	1.897	0.000	0.000	-0.332	-0.067		16.642	-2.566	1.018	0.000	0.000	0.000	0.000	MARKER	0.00000	0.0000

LINEAR LATTICE PARAMETERS FOR BEAM LINE: "JBTA ", RANGE = "#S / #E"
DELTA(P)/P = 0.000000 symm = F PAGE 3

ELEMENT SEQUENCE			I	HORIZONTAL							I	VERTICAL							
POS. NO.	ELEMENT NAME	OCC. NO.	DIST [M]	I I	BETAX [M]	ALFAX [1]	MUX [2PI]	X(CO) [MM]	PX(CO) [.001]	DX [M]	DPX [1]	I I	BETAY [M]	ALFAY [1]	MUY [2PI]	Y(CO) [MM]	PY(CO) [.001]	DY [M]	DPY [1]	ELEMENT	LENGTH	STRENGTH
81	DR183	1	59.344		10.899	1.534	1.904	0.000	0.000	-0.367	-0.067		19.465	-2.805	1.023	0.000	0.000	0.000	0.000	DRIFT	0.52550	0.0000
82	QV15	1	59.902		10.440	-0.682	1.913	0.000	0.000	-0.426	-0.147		20.370	1.247	1.027	0.000	0.000	0.000	0.000	QUADRUPO	0.55880	-0.3647
83	DRQ15	1	60.139		10.770	-0.715	1.916	0.000	0.000	-0.461	-0.147		19.788	1.217	1.029	0.000	0.000	0.000	0.000	DRIFT	0.23630	0.0000
84	SHOLE	1	60.139		10.770	-0.715	1.916	0.000	0.000	-0.461	-0.147		19.788	1.217	1.029	0.000	0.000	0.000	0.000	MARKER	0.00000	0.0000
END	L6	1	60.139		10.770	-0.715	1.916	0.000	0.000	-0.461	-0.147		19.788	1.217	1.029	0.000	0.000	0.000	0.000			
BEGIN	L7	1	60.139		10.770	-0.715	1.916	0.000	0.000	-0.461	-0.147		19.788	1.217	1.029	0.000	0.000	0.000	0.000			
85	DRQ15B	1	62.401		14.723	-1.032	1.945	0.000	0.000	-0.793	-0.147		14.923	0.934	1.050	0.000	0.000	0.000	0.000	DRIFT	2.26190	0.0000
86	L2OSPTM1	1	63.466		17.080	-1.182	1.956	0.000	0.000	-0.911	-0.075		13.016	0.852	1.062	0.000	0.000	0.000	0.000	RBEND	1.06514	0.0655
87	DRL20A1	1	63.496		17.150	-1.186	1.956	0.000	0.000	-0.913	-0.075		12.966	0.848	1.063	0.000	0.000	0.000	0.000	DRIFT	0.02987	0.0000
88	L2OSPTMT	1	63.496		17.150	-1.186	1.956	0.000	0.000	-0.913	-0.075		12.966	0.848	1.063	0.000	0.000	0.000	0.000	HKICK	0.00000	0.0000
89	DRL20A2	1	63.525		17.221	-1.190	1.956	0.000	0.000	-0.915	-0.075		12.915	0.844	1.063	0.000	0.000	0.000	0.000	DRIFT	0.02987	0.0000
90	L2OSPTM2	1	64.560		19.832	-1.335	1.965	0.000	0.000	-0.957	-0.005		11.261	0.751	1.077	0.000	0.000	0.000	0.000	RBEND	1.03454	0.0637
91	DRL20B	1	65.033		21.126	-1.402	1.969	0.000	0.000	-0.959	-0.005		10.582	0.685	1.084	0.000	0.000	0.000	0.000	DRIFT	0.47272	0.0000
END	L7	1	65.033		21.126	-1.402	1.969	0.000	0.000	-0.959	-0.005		10.582	0.685	1.084	0.000	0.000	0.000	0.000			
END	JBTA	1	65.033		21.126	-1.402	1.969	0.000	0.000	-0.959	-0.005		10.582	0.685	1.084	0.000	0.000	0.000	0.000			

TOTAL LENGTH =	65.032629	MUX =	1.968994	MUY =	1.083719
DELTA(S) =	0.000000 mm	DMUX =	-6.104422	DMUY =	-1.196639
		BETAX(MAX) =	24.985518	BETAY(MAX) =	25.002394
		DX(MAX) =	2.850000	DY(MAX) =	0.000000