IMPROVEMENT of the BOOSTER HEAVY ION INJECTION LINE

**BOOSTER TECHNICAL NOTE
NO. 192**

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The layout and beam optics of the new design of the heavy ion injection line for the AGS booster have been described in reference 1 by R.C. Gupta et al. In their design, at the booster injection point there is vertical dispersion mismatch and MAD program was used. I have run the same lattice with both MAD and SYNCH programs. Dr. Milutinovic has run it with program PATRIS. The outputs from different programs are really different slightly. The output of MAD program is shown in Table 1, the input data and output of SYNCH are shown in Table 2 and Table 3 respectively. The Twiss parameters and dispersion functions at the booster injection point from different programs are shown in the following table, Table 4,

Table 4

	β_x	α_x	η_x	η'_x	μ_x	β_y	α_y	η_y	η'_y	μ_y
MAD	13.976	-0.208	2.82	0.286	1.545	3.568	0.304	0.391	0.119	0.973
SYNCH	13.976	-0.208	2.82	0.286	1.545	3.547	0.307	0.485	0.057	0.972
PATRIS ²	12.550	-0.073	2.82	0.286	1.552	3.514	0.359	0.391	0.119	0.967

The dispersion functions from MAD coincide with those from PATRIS and the Twiss parameters from MAD coincide with those from SYNCH. The discrepancy is produced due to the tilt of bending magnets. From the above results, one can assume that, the output of MAD is reliable even though in its output there is a warning message.

The focusing parameters and the location of the quadrupoles have been tuned so that to get a better match at the booster injection point. In this process, MAD program was used. The output are shown in Table 5.

Next, the emittance dilution due to dispersion mismatch will be estimated. Suppose, the Twiss parameters in y-direction at the booster injection point are α , β , γ , η_y and η'_y , the dispersion function of the injection line at the injection point are $\eta_{y\ell}$, $\eta'_{y\ell}$ and momentum error is $\frac{\Delta p}{p}$, then the emittance dilution factor F is expressed as follows³

$$F = \left[1 + \sqrt{\frac{\epsilon_p}{\epsilon_o}} \right]^2 \quad (1)$$

where ϵ_o is the emittance of the injected beam and ϵ_p can be expressed as follows

$$\epsilon_p = \left(\frac{\Delta p}{p} \right)^2 \left[\gamma (\eta_{y\ell} - \eta_y)^2 + 2\alpha (\eta_{y\ell} - \eta_y) (\eta'_{y\ell} - \eta'_y) + \beta (\eta'_{y\ell} - \eta'_y)^2 \right] \quad (2)$$

For the original injection line lattice, the emittance dilution factor due to vertical dispersion mismatch will be:

$$F = \left[1 + \frac{\Delta p}{p} \left(\frac{0.126}{\epsilon_o} \right)^{1/2} \right]^2. \quad (3)$$

From reference 4 $\epsilon_o \approx 1 \text{ mm}\cdot\text{mrad}$, then

$$F = \left[1 + 0.35 \frac{\Delta p}{p} \right]^2 \quad (4)$$

where $\frac{\Delta p}{p}$ is expressed in 10^{-3} . The emittance dilution factors F corresponding to various $\frac{\Delta p}{p}$ are shown in the following table,

F	1.83	1.38	1.14
$\frac{\Delta p}{p} (10^{-3})$	1	0.5	0.2

For the improved lattice, F due to η'_y mismatch can be expressed as follows

$$F = \left[1 + 5.7 \times 10^{-3} \frac{\Delta p}{p} \right]^2. \quad (5)$$

F due to β_y , α_y small mismatch is 1.007. Both F 's equal 1 approximately. The emittance dilution is negligibly small. One thing should be pointed out is that the maximum β_y in this lattice is approximately 100 meters, but the beam size remains well within the 4'' aperture of the quadrupoles. Another possibility to improve this line is to tune the upstream line focusing parameters or to tune the whole line from Tandem to booster injection point.

Acknowledgments

I am thankful to Dr. A.G. Ruggiero for valuable discussion and Dr. S. Tepikian and J. Milutinovic for their help in running SYNCH program.

References

1. R.C. Gupta, R. Damm, Y.Y. Lee and W.T. Weng, H^- and Heavy Ion Injection Lines for the Booster, Booster Technical Note No. 90, Sept. 1987.
2. J. Milutinovic, private communication, 1991.
3. J. Xu, J. Claus and A.G. Ruggiero, A Feedback Device to Damp the Coherent Oscillations from Injection Errors in RHIC, AD/RHIC Technical Note No 74, 1990.
4. Booster Design Manual, p. 4-16.

Table 1.

1" MAD" Version 7.2/VAX Copyright (C) 1988 by CERN.

Date and time of this run: 25-APR-9 16:16:12

MQFC3:QUAD,L=0.25,K1=.554569
MDR:DRIFT,L=.30
HIKICK:SBEND,L=1.6,ANGLE=-.180056

HILA:DRIFT,L=2.0
HILB:DRIFT,L=.30
HILC:DRIFT,L=.30
HILD:DRIFT,L=.30
HILE:DRIFT,L=1.5
HILF:DRIFT,L=.5
HILG:DRIFT,L=3.0
HILH:DRIFT,L=.40
HILI:DRIFT,L=1.30
HILJ:DRIFT,L=.40
HILK:DRIFT,L=1.70
HILL:DRIFT,L=.50
HILM:DRIFT,L=3
HILN:DRIFT,L=1.0

HIDC:SBEND,L=.450,ANGLE=-.34906585,TILT=.11017
HIDB:SBEND,L=.450,ANGLE=-.34906585,TILT=.110170
HIDA:SBEND,L=.450,ANGLE=-.34906585,TILT=0

HIQFA:QUAD,L=.150,K1=3.01531400678
HIQFB:QUAD,L=.150,K1=2.97376034875
HIQFC:QUAD,L=.150,K1=3.49999999916
HIQFD:QUAD,L=.150,K1=1.987117

HIQDA:QUAD,L=.150,K1=-1.08624681663
HIQDB:QUAD,L=.150,K1=0
HIQDC:QUAD,L=.150,K1=-2.0000
HIQDD:QUAD,L=.150,K1=-2.96600878394
HIQDE:QUAD,L=.1500,K1=-3.1999999
HIQDF:QUAD,L=.150,K1=-2.00000
HIQDG:QUAD,L=.150,K1=-1.46334111601

HIBST:LINE=(2*HIDC,HILM,2*HIQDG,HILN,2*HIKICK,MDR,MQFC3)
HINTER:LINE=(HILD,2*HIQDC,HILE,2*HIQFA,HILF,2*HIQDD,HILG,2*HIQFB,HILH,&
2*HIQDE,HILI,2*HIQFC,HILJ,2*HIQDF,HILK,2*HIQFD,HILL)
HILINC:LINE=(HIQDA,HILA,2*HIDA,HILB,2*HIQDB,HILC,2*HIDB)
HILINE:LINE=(HILINC,HINTER,HIBST)

USE,HILINE

ELEMENT SEQUENCE			I			H O R I Z O N T A L			I			V E R T I C A L			D Y		
POS. NO.	ELEMENT NAME	NO.	DIST [M]	I	BETAX [M]	ALFAX [1]	MUX [2PI]	X(CO) [MM]	PX(CO) [.001]	DX [M]	DPX [1]	BETAY [M]	ALFAY [1]	MUY [2PI]	Y(CO) [MM]	PY(CO) [.001]	DPY [1]
BEGIN	HILINE	1	0.000		3.875	3.191	0.000	0.000	0.000	0.000	0.000	12.322	0.401	0.000	0.000	0.000	0.000
BEGIN	HILINC	1	0.000		3.875	3.191	0.000	0.000	0.000	0.000	0.000	12.322	0.401	0.000	0.000	0.000	0.000
1	HIQDA	1	0.150		3.063	2.267	0.007	0.000	0.000	0.000	0.000	11.907	2.343	0.002	0.000	0.000	0.000
2	HILA	1	2.150		2.012	-1.741	0.358	0.000	0.000	0.000	0.000	4.716	1.253	0.045	0.000	0.000	0.000
3	HIDA	1	2.600		3.608	-1.662	0.384	0.000	0.000	0.000	0.000	3.698	1.008	0.062	0.000	0.000	0.000
4	HIDA	2	3.050		4.767	-0.806	0.401	0.000	0.000	0.000	0.000	2.904	0.762	0.084	0.000	0.000	0.000
5	HILB	1	3.350		5.281	-0.910	0.410	0.000	0.000	0.000	0.000	2.493	0.599	0.102	0.000	0.000	0.000
6	HIQDB	1	3.500		5.562	-0.962	0.415	0.000	0.000	0.000	0.000	2.326	0.517	0.112	0.000	0.000	0.000
7	HIQDB	2	3.650		5.858	-1.014	0.419	0.000	0.000	0.000	0.000	2.183	0.435	0.122	0.000	0.000	0.000
8	HILC	1	3.950		6.497	-1.117	0.427	0.000	0.000	0.000	0.000	1.971	0.272	0.145	0.000	0.000	0.000
9	HIDB	1	4.400		6.740	0.599	0.437	0.000	0.000	0.000	0.000	1.834	0.033	0.184	0.000	0.000	0.000
10	HIDB	2	4.850		5.504	2.038	0.449	0.000	0.000	0.000	0.000	1.912	-0.207	0.222	0.000	0.000	0.000
END	HILINC	1	4.850		5.504	2.038	0.449	0.000	0.000	0.000	0.000	1.912	-0.207	0.222	0.000	0.000	0.000
BEGIN	HINTER	1	4.850		5.504	2.038	0.449	0.000	0.000	0.000	0.000	1.912	-0.207	0.222	0.000	0.000	0.000
11	HILD	1	5.150		4.365	1.757	0.459	0.000	0.000	0.000	0.000	2.086	-0.371	0.246	0.000	0.000	0.000
12	HIQDC	1	5.300		4.043	0.424	0.464	0.000	0.000	0.000	0.000	2.113	0.190	0.257	0.000	0.000	0.000
13	HIQDC	2	5.450		4.103	-0.832	0.470	0.000	0.000	0.000	0.000	1.975	0.717	0.269	0.000	0.000	0.000
14	HILE	1	6.950		7.526	-1.450	0.514	0.000	0.000	0.000	0.000	1.549	-0.433	0.433	0.000	0.000	0.000
15	HIQFA	1	7.100		7.452	1.935	0.517	0.000	0.000	0.000	0.000	1.810	-1.346	0.447	0.000	0.000	0.000
16	HIQFA	2	7.250		6.417	4.807	0.520	0.000	0.000	0.000	0.000	2.394	-2.633	0.459	0.000	0.000	0.000
17	HILF	1	7.750		2.549	2.929	0.540	0.000	0.000	0.000	0.000	5.855	-4.289	0.480	0.000	0.000	0.000
18	HIQDD	1	7.900		1.891	1.554	0.551	0.000	0.000	0.000	0.000	6.776	-1.714	0.484	0.000	0.000	0.000
19	HIQDD	2	8.050		1.574	0.604	0.565	0.000	0.000	0.000	0.000	6.838	1.309	0.488	0.000	0.000	0.000
20	HILG	1	11.050		5.752	-1.996	0.828	0.000	0.000	0.000	0.000	2.557	0.119	0.615	0.000	0.000	0.000
21	HIQFB	1	11.200		5.967	0.593	0.832	0.000	0.000	0.000	0.000	2.703	-1.119	0.624	0.000	0.000	0.000
22	HIQFB	2	11.350		5.411	3.028	0.836	0.000	0.000	0.000	0.000	3.258	-2.663	0.632	0.000	0.000	0.000
23	HILH	1	11.750		3.290	2.276	0.851	0.000	0.000	0.000	0.000	5.787	-3.657	0.647	0.000	0.000	0.000
24	HIQDE	1	11.900		2.859	0.660	0.859	0.000	0.000	0.000	0.000	6.480	-0.852	0.651	0.000	0.000	0.000
25	HIQDE	2	12.050		2.874	-0.761	0.867	0.000	0.000	0.000	0.000	6.274	2.193	0.655	0.000	0.000	0.000
26	HILI	1	13.350		5.780	-1.474	0.919	0.000	0.000	0.000	0.000	2.137	0.989	0.712	0.000	0.000	0.000
27	HIQFC	1	13.500		5.768	1.551	0.923	0.000	0.000	0.000	0.000	2.018	-0.179	0.724	0.000	0.000	0.000
28	HIQFC	2	13.650		4.897	4.101	0.927	0.000	0.000	0.000	0.000	2.249	-1.404	0.735	0.000	0.000	0.000
29	HILJ	1	14.050		2.199	2.646	0.947	0.000	0.000	0.000	0.000	3.584	-1.933	0.758	0.000	0.000	0.000
30	HIQDF	1	14.200		1.564	1.645	0.960	0.000	0.000	0.000	0.000	4.017	-0.910	0.764	0.000	0.000	0.000
31	HIQDF	2	14.350		1.181	0.946	0.978	0.000	0.000	0.000	0.000	4.114	0.273	0.770	0.000	0.000	0.000
32	HILK	1	16.050		2.600	-1.781	1.267	0.000	0.000	0.000	0.000	3.940	-0.171	0.839	0.000	0.000	0.000
33	HIQFD	1	16.200		3.040	-1.105	1.275	0.000	0.000	0.000	0.000	4.177	-1.436	0.845	0.000	0.000	0.000
34	HIQFD	2	16.350		3.244	-0.235	1.283	0.000	0.000	0.000	0.000	4.827	-2.962	0.851	0.000	0.000	0.000
35	HILL	1	16.850		3.560	-0.397	1.306	0.000	0.000	0.000	0.000	8.296	-3.975	0.863	0.000	0.000	0.000
END	HINTER	1	16.850		3.560	-0.397	1.306	0.000	0.000	0.000	0.000	8.296	-3.975	0.863	0.000	0.000	0.000
BEGIN	HIBST	1	16.850		3.560	-0.397	1.306	0.000	0.000	0.000	0.000	8.296	-3.975	0.863	0.000	0.000	0.000
36	HIDC	1	17.300		3.541	0.437	1.326	0.000	0.000	0.000	0.000	12.267	-4.847	0.870	0.000	0.000	0.000
37	HIDC	2	17.750		2.835	1.069	1.348	0.000	0.000	0.000	0.000	17.011	-5.691	0.875	0.000	0.000	0.000
38	HILM	1	18.050		2.261	0.842	1.367	0.000	0.000	0.000	0.000	20.603	-6.280	0.878	0.000	0.000	0.000
39	HIQDG	1	18.200		2.095	0.275	1.378	0.000	0.000	0.000	0.000	21.818	-1.735	0.879	0.000	0.000	0.000
40	HIQDG	2	18.350		2.092	-0.255	1.390	0.000	0.000	0.000	0.000	21.621	3.036	0.880	0.000	0.000	0.000
41	HILN	1	19.350		3.112	-0.764	1.454	0.000	0.000	0.000	0.000	16.022	2.563	0.889	0.000	0.000	0.000
42	HIKICK	1	20.950		6.693	-1.450	1.511	0.000	0.000	0.000	0.000	9.030	1.807	0.910	0.000	0.000	0.000
43	HIKICK	2	22.550		12.194	-1.950	1.539	0.000	0.000	0.000	0.000	4.456	1.051	0.950	0.000	0.000	0.000
44	MDR	1	22.850		13.400	-2.069	1.542	0.000	0.000	0.000	0.000	3.868	0.910	0.962	0.000	0.000	0.000
45	MQFC3	1	23.100		13.976	-0.208	1.545	0.000	0.000	0.000	0.000	3.568	0.304	0.973	0.000	0.000	0.000
END	HIBST	1	23.100		13.976	-0.208	1.545	0.000	0.000	0.000	0.000	3.568	0.304	0.973	0.000	0.000	0.000
END	HILINE	1	23.100		13.976	-0.208	1.545	0.000	0.000	0.000	0.000	3.568	0.304	0.973	0.000	0.000	0.000

TABLE 2

BOOS		TABLE 2									
RUN		0.30									
MDR	DRF	2.00									
LA	DRF	0.30									
LB	DRF	0.30									
LC	DRF	0.30									
LD	DRF	0.30									
LE	DRF	1.50									
LF	DRF	0.50									
LG	DRF	3.00									
LH	DRF	0.40									
LI	DRF	1.30									
LJ	DRF	0.40									
LK	DRF	1.70									
LL	DRF	0.50									
LM	DRF	0.30									
LN	DRF	1.00									
R+	ROTZ	6.31228									
R-	ROTZ	-6.31228									
DB	MAG	0.45	0.0	0.45							
DBR	MM	R- DB	R+								
R+	ROTZ	6.31228									
R-	ROTZ	-6.31228									
DC	MAG	0.45	0.0	0.45							
DCR	MM	R- DC	R+								
DA	MAG	0.45	0.0	0.45							
CK	MAG	1.6	0.0	1.6							
KFA	=	.45229710									
KFB	=	.44506405									
KFC	=	.52500000									
KFD	=	.29806755									
KDA	=	-.1629370									
KDB	=	.00000000									
KDC	=	-.30000000									
KDD	=	-.44490132									
KDE	=	-.47999999									
KDF	=	-.30000000									
KDG	=	-.21950117									
BETO	IBET	0	3.875	3.191							
		0	12.232	0.401							
B0	SUB										
FC3	MAG	.25	0.1386423	.25							
FA	MAG	.15	KFA	.15							
FB	MAG	.15	KFB	.15							
FC	MAG	.15	KFC	.15							
FD	MAG	.15	KFD	.15							
QDA	MAG	.15	KDA	.15							
QDB	MAG	.15	KDB	.15							
QDC	MAG	.15	KDC	.15							
QDD	MAG	.15	KDD	.15							
QDE	MAG	.15	KDE	.15							
QDF	MAG	.15	KDF	.15							
QDG	MAG	.15	KDG	.15							
BST	BML	DCR	DCR	LM	QDG	QDG	LN				

Table 3.

SYNCH VERSION IBM 3090

SYNCH RUN BOOS
29-APR-91 11:00:07

POS	S	QX	BX	AX	X	DX	QY	BY	AY	Y	DY
0	0.0000	0.000000	3.8750	3.191000	0.000000	0.000000	0.000000	12.2320	0.401000	0.000000	0.000000
1 QDA	0.1500	0.006960	3.0630	2.266578	0.000000	0.000000	0.001977	11.8192	2.328284	0.000000	0.000000
2 LA	2.1500	0.357847	2.0116	-1.740888	0.000000	0.000000	0.045314	4.6791	1.241766	0.000000	0.000000
3 DA	2.6000	0.384011	3.6084	-1.662296	0.077746	0.342020	0.062627	3.6716	0.997300	0.000000	0.000000
4 DA	3.0500	0.400964	4.7665	-0.805898	0.301605	0.642788	0.084707	2.8840	0.752833	0.000000	0.000000
5 LB	3.3500	0.410486	5.2812	-0.909713	0.494441	0.642788	0.102594	2.4812	0.589856	0.000000	0.000000
6 QDB	3.5000	0.414892	5.5619	-0.961621	0.590859	0.642788	0.112558	2.3165	0.508367	0.000000	0.000000
7 QDB	3.6500	0.419074	5.8582	-1.013529	0.687278	0.642788	0.123199	2.1762	0.426878	0.000000	0.000000
8 LC	3.9500	0.426817	6.4974	-1.117345	0.880114	0.642788	0.146347	1.9689	0.263901	0.000000	0.000000
9 DBR	4.4000	0.437431	6.7404	0.598969	1.188439	0.713761	0.184338	1.8387	0.025217	-0.008548	-0.037604
10 DBR	4.8500	0.448965	5.5036	2.038287	1.509696	0.699695	0.222784	1.9235	-0.213606	-0.034007	-0.075154
11 LD	5.1500	0.458713	4.3649	1.757312	1.719604	0.699695	0.246626	2.1006	-0.376676	-0.056553	-0.075154
12 QDC	5.3000	0.464440	4.0425	0.424014	1.864184	1.235257	0.257839	2.1292	0.189059	-0.066474	-0.056630
13 QDC	5.4500	0.470348	4.1028	-0.831810	2.092967	1.826613	0.269359	1.9906	0.721270	-0.073415	-0.035567
14 LE	6.9500	0.513850	7.5260	-1.450359	4.832887	1.826613	0.432675	1.5451	-0.424267	-0.126766	-0.035567
15 FA	7.1000	0.517002	7.4516	1.935044	4.940774	-0.396258	0.447161	1.8030	-1.333817	-0.136487	-0.094767
16 FA	7.2500	0.520416	6.4168	4.807087	4.715346	-2.592416	0.458822	2.3820	-2.613597	-0.155519	-0.160433
17 LF	7.7500	0.540143	2.5490	2.928578	3.419139	-2.592416	0.480263	5.8175	-4.257323	-0.235736	-0.160433
18 QDD	7.9000	0.551147	1.8911	1.554099	3.140661	-1.141245	0.484037	6.7313	-1.698507	-0.251712	-0.051393
19 QDD	8.0500	0.555154	1.5745	0.603782	3.072944	0.233339	0.487528	6.7919	1.303714	-0.250983	0.061058
20 LG	11.0500	0.827695	5.7515	-1.996129	3.772962	0.233339	0.615756	2.5469	0.111282	-0.067810	0.061058
21 FB	11.2000	0.831726	5.9667	0.593434	3.682053	-1.438701	0.624975	2.6954	-1.123236	-0.060830	0.032526
22 FB	11.3500	0.835881	5.4111	3.027682	3.346149	-3.015014	0.633133	3.2513	-2.665140	-0.057943	0.006182
23 LH	11.7500	0.850993	3.2896	2.276133	2.140143	-3.015014	0.647837	5.7821	-3.662028	-0.055470	0.006182
24 QDE	11.9000	0.858874	2.8594	0.660390	1.759953	-2.084567	0.651692	6.4771	-0.859260	-0.052569	0.032268
25 QDE	12.0500	0.867306	2.8741	-0.760552	1.507242	-1.305111	0.655392	6.2733	2.185092	-0.045905	0.056888
26 LI	13.3500	0.918974	5.7796	-1.474486	-0.189403	-1.305111	0.713010	2.1477	0.988445	0.026953	0.056045
27 FC	13.5000	0.923055	5.7678	1.551078	-0.375201	-1.155922	0.724603	2.0302	-0.184869	0.036539	0.072603
28 FC	13.6500	0.927489	4.8971	4.100744	-0.531646	-0.916300	0.735893	2.2646	-1.417962	0.049021	0.094916
29 LJ	14.0500	0.946939	2.1986	2.645500	-0.898166	-0.916300	0.758227	3.6116	-1.949733	0.086988	0.094916
30 QDF	14.2000	0.959923	1.5644	1.645418	-1.056929	-1.208470	0.764425	4.0485	-0.919083	0.099169	0.066888
31 QDF	14.3500	0.977652	1.1814	0.945980	-1.263432	-1.555225	0.770210	4.1467	0.274535	0.106904	0.035860
32 QK	16.0500	1.266795	2.6002	-1.780546	-3.907314	-1.555225	0.839085	3.9627	-0.166306	0.167867	0.035860
33 FD	16.2000	1.275227	3.0396	-1.105021	-4.051840	-0.364602	0.844982	4.1998	-1.438141	0.177052	0.087074
34 FD	16.3500	1.282777	3.2436	-0.234802	-4.015882	0.842251	0.850311	4.8515	-2.971031	0.194184	0.142196
35 LL	16.8500	1.306281	3.5597	-0.397439	-3.594752	0.842251	0.862842	8.3289	-3.983800	0.265282	0.142196
36 DCR	17.3000	1.326102	3.5411	0.436955	-3.086397	1.394313	0.869916	12.3087	-4.856158	0.337609	0.178846
37 DCR	17.7500	1.348329	2.8347	1.069289	-2.364859	1.780236	0.874858	17.0613	-5.700464	0.426372	0.215237
38 LW	18.0500	1.367232	2.2612	0.842467	-1.830789	1.780236	0.877402	20.6583	-6.289433	0.490943	0.215237
39 QDG	18.2000	1.378269	2.0953	0.275338	-1.592508	1.405554	0.878519	21.8749	-1.732228	0.514991	0.104531
40 QDG	18.3500	1.389743	2.0923	-0.255130	-1.406805	1.077278	0.879609	21.6749	3.050019	0.522130	-0.009607
41 LN	19.3500	1.458336	3.1116	-0.764114	-0.329526	1.077278	0.888146	16.0492	2.575131	0.512523	-0.009607
42 CK	20.9500	1.510525	6.6934	-1.450294	1.246492	0.887419	0.909367	9.0260	1.814351	0.491752	-0.009607
43 CK	22.5500	1.538706	12.1941	-1.950423	2.494895	0.668867	0.950045	4.4373	1.053571	0.481780	-0.009607
44 MDR	22.8500	1.542442	13.3999	-2.068612	2.695555	0.668867	0.961611	3.8480	0.910525	0.478898	-0.009607
45 FC3	23.1000	1.545333	13.9757	-0.207937	2.815228	0.285746	0.972451	3.5469	0.307260	0.484806	0.057006

7	HILC	1	3.350	6.510	-0.928	0.427	0.000	0.000	0.494	0.643	8.179	0.066	0.057	0.000	0.000	0.000	0.000
8	HIQFB	1	3.500	6.499	0.999	0.431	0.000	0.000	0.579	0.482	8.534	-2.464	0.060	0.000	0.000	0.000	0.000
9	HIQFB	2	3.650	5.928	2.750	0.434	0.000	0.000	0.638	0.299	9.702	-5.443	0.063	0.000	0.000	0.000	0.000
10	HILC	2	3.950	4.408	2.317	0.444	0.000	0.000	0.728	0.299	13.252	-6.390	0.067	0.000	0.000	0.000	0.000
11	HIDB	1	4.400	2.258	2.268	0.466	0.000	0.000	0.894	0.431	19.617	-7.748	0.072	0.000	0.000	0.000	0.015
12	HIDB	2	4.850	0.644	1.171	0.526	0.000	0.000	1.108	0.511	27.184	-9.061	0.075	0.000	0.000	0.012	0.023
END	HILINC	1	4.850	0.644	1.171	0.526	0.000	0.000	1.108	0.511	27.184	-9.061	0.075	0.000	0.000	0.012	0.023
BEGIN	HINTER	1	5.350	0.393	-0.669	0.757	0.000	0.000	1.363	0.511	37.009	-10.589	0.077	0.000	0.000	0.024	0.023
13	HILD	1	5.500	0.678	-1.233	0.804	0.000	0.000	1.441	0.535	40.153	-10.352	0.078	0.000	0.000	0.027	0.023
14	HIQDB	1	5.650	1.134	-1.809	0.831	0.000	0.000	1.523	0.561	43.209	-10.007	0.078	0.000	0.000	0.031	0.022
15	HIQDB	2	6.150	3.885	-3.692	0.870	0.000	0.000	1.804	0.561	53.801	-11.177	0.080	0.000	0.000	0.042	0.022
16	HILD	2	6.300	5.000	-3.705	0.875	0.000	0.000	1.873	0.357	58.140	-17.909	0.080	0.000	0.000	0.046	0.027
17	HIQFC	1	6.450	6.083	-3.474	0.879	0.000	0.000	1.911	0.148	64.665	-25.834	0.081	0.000	0.000	0.050	0.033
18	HIQFC	2	6.950	10.095	-4.548	0.889	0.000	0.000	1.985	0.148	93.083	-31.002	0.082	0.000	0.000	0.066	0.033
19	HILD	3	7.100	12.278	-10.335	0.892	0.000	0.000	2.076	1.068	95.974	12.173	0.082	0.000	0.000	0.069	0.001
20	HIQDC	1	7.250	16.582	-19.012	0.893	0.000	0.000	2.309	2.062	86.107	52.095	0.082	0.000	0.000	0.067	-0.030
21	HIQDC	2	7.750	41.058	-29.941	0.896	0.000	0.000	3.340	2.062	41.895	36.331	0.084	0.000	0.000	0.052	-0.030
22	HILD	4	7.900	48.203	-16.891	0.897	0.000	0.000	3.563	0.903	33.484	20.671	0.084	0.000	0.000	0.049	-0.013
23	HIQFD	1	8.050	50.858	-0.510	0.897	0.000	0.000	3.608	0.300	29.073	9.227	0.085	0.000	0.000	0.048	0.003
24	HIQFD	2	10.850	53.910	-0.580	0.906	0.000	0.000	2.768	-0.300	0.630	0.931	0.199	0.000	0.000	0.057	0.003
25	HILE	1	13.650	57.351	-0.649	0.914	0.000	0.000	1.928	-0.300	18.641	-7.364	0.546	0.000	0.000	0.067	0.003
26	HILE	2	13.800	54.712	17.944	0.914	0.000	0.000	1.835	-0.932	21.943	-15.014	0.549	0.000	0.000	0.069	0.026
27	HIQFD	3	13.950	46.940	32.999	0.915	0.000	0.000	1.651	-1.516	27.954	-25.726	0.549	0.000	0.000	0.074	0.050
28	HIQFD	4	14.450	19.746	21.389	0.917	0.000	0.000	0.892	-1.516	59.608	-37.582	0.551	0.000	0.000	0.099	0.050
29	HILD	5	14.600	14.949	11.322	0.919	0.000	0.000	0.693	-1.157	66.915	-10.013	0.551	0.000	0.000	0.103	0.003
30	HIQDC	3	14.750	12.639	4.422	0.921	0.000	0.000	0.541	-0.878	65.346	20.232	0.551	0.000	0.000	0.100	-0.043
31	HIQDC	4	15.250	8.623	3.609	0.928	0.000	0.000	0.102	-0.878	46.684	17.092	0.553	0.000	0.000	0.079	-0.043
32	HILD	6	15.400	7.447	4.190	0.931	0.000	0.000	-0.030	-0.882	42.419	11.498	0.553	0.000	0.000	0.073	-0.035
33	HIQFC	3	15.550	6.137	4.496	0.935	0.000	0.000	-0.161	-0.871	39.708	6.670	0.554	0.000	0.000	0.068	-0.027
34	HIQFC	4	16.050	2.505	2.768	0.955	0.000	0.000	-0.597	-0.871	33.324	6.098	0.556	0.000	0.000	0.054	-0.027
35	HILD	7	16.350	1.758	2.219	0.966	0.000	0.000	-0.728	-0.883	31.437	6.471	0.557	0.000	0.000	0.050	-0.028
36	HIQDB	3	16.200	1.171	1.694	0.983	0.000	0.000	-0.862	-0.896	29.449	6.777	0.558	0.000	0.000	0.046	-0.029
37	HIQDB	4	16.850	0.303	0.043	1.141	0.000	0.000	-1.310	-0.896	23.070	5.980	0.561	0.000	0.000	0.031	-0.029
38	HILD	8	16.850	0.303	0.043	1.141	0.000	0.000	-1.310	-0.896	23.070	5.980	0.561	0.000	0.000	0.031	-0.029
BEGIN	HINTER	1	16.850	0.303	0.043	1.141	0.000	0.000	-1.310	-0.896	23.070	5.980	0.561	0.000	0.000	0.031	-0.029
39	HIDC	1	17.300	0.875	-1.262	1.305	0.000	0.000	-1.705	-0.840	17.982	5.320	0.564	0.000	0.000	0.019	-0.023
40	HIDC	2	17.750	2.397	-1.983	1.354	0.000	0.000	-2.051	-0.684	13.502	4.630	0.569	0.000	0.000	0.013	-0.006
41	HILF	1	17.950	3.273	-2.395	1.366	0.000	0.000	-2.188	-0.684	11.717	4.298	0.571	0.000	0.000	0.011	-0.006
42	HIQFE	1	18.100	3.271	2.410	1.373	0.000	0.000	-2.052	2.458	13.020	-13.612	0.573	0.000	0.000	0.012	0.011
43	HILF	2	18.300	2.390	1.994	1.384	0.000	0.000	-1.561	2.458	19.037	-16.474	0.575	0.000	0.000	0.014	0.011
44	HIQDD	1	18.450	2.148	-0.306	1.395	0.000	0.000	-1.298	1.078	21.161	3.013	0.576	0.000	0.000	0.015	-0.003
45	HILG	1	19.350	3.111	-0.764	1.451	0.000	0.000	-0.328	1.078	16.124	2.584	0.584	0.000	0.000	0.012	-0.003
46	HIKICK	1	20.950	6.693	-1.450	1.508	0.000	0.000	1.250	0.889	9.073	1.822	0.605	0.000	0.000	0.007	-0.003
47	HIKICK	2	22.550	12.194	-1.950	1.536	0.000	0.000	2.500	0.670	4.460	1.060	0.646	0.000	0.000	0.002	-0.003
48	MDR	1	22.850	13.400	-2.069	1.540	0.000	0.000	2.701	0.670	3.867	0.917	0.657	0.000	0.000	0.001	-0.003
49	MQFC3	1	23.100	13.976	-0.208	1.543	0.000	0.000	2.821	0.286	3.563	0.311	0.668	0.000	0.000	0.000	-0.003
END	HIBST	1	23.100	13.976	-0.208	1.543	0.000	0.000	2.821	0.286	3.563	0.311	0.668	0.000	0.000	0.000	-0.003
END	HILINE	1	23.100	13.976	-0.208	1.543	0.000	0.000	2.821	0.286	3.563	0.311	0.668	0.000	0.000	0.000	-0.003
TOTAL LENGTH = 23.100000 mm																	
DELTA(S) = 0.000000																	
MUY = 1.542899																	
DMUY = -4.581355																	
BETAY(MAX) = 57.350592																	
DY(MAX) = 3.608452																	

WARNING ## TWISS1: TWISS PARAMETERS FOR DELTA(P)/P = 0.000000000 MAY BE WRONG DUE TO COUPLING.

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