PS/LPI Note 85-27
23. 09. 1985

TEST OF ORBCOR FOR EPA

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1. Introduction

The on-line orbit correction program ORBCOR, implemented by one of the authors (1) in the PRDEV computer is built as a general program applicable to any machine.

It has already been used and checked with the PS (2) as a real machine, correcting measured closed orbits.

The same program has now been used to correct a simulated orbit in a virtual EPA machine with the particularity that the closed orbit correction is foreseen to be made by displacement of the lattice quadrupoles instead of corrector dipoles powering.

2. Calibration of the correctors

ORBCOR calculates the deflection angle θ to be provided by the correctors. A calibration factor C is then used to convert this angle into a current I (A) (in case of corrector dipoles) or a displacement Δ (mm) (in case of quadrupoles move).

a) The corrector in a dipole

$$\left.\begin{aligned} \theta &= B\ell/B\rho \\ B\ell &= C\,I \end{aligned}\right\} \rightarrow I(A) = \frac{B\rho}{C}\,\theta\ (\text{rad})$$

b) The corrector in a quadrupole

$$\left.\begin{aligned} \theta &= G\ell\Delta/B\rho \\ G\ell &= C \end{aligned}\right\} \rightarrow \Delta\ (\text{mm}) = \frac{B\rho}{C}\,\theta\ (\text{mrad}) = \frac{\theta\ (\text{mrad})}{k\ell}$$

By using this definition of the calibration factor, the conversion method is identical for the two cases. However, for the second case, the calibration factor depends on the beam energy, thus it will have to be updated if the operating energy or the quadrupole strength is significantly modified.

3. ORBCOR data

Three machine-oriented files have to be provided.

a) Twiss file

calculated with MAD in the IBM and first transmitted in the PRDEV then converted into a random access file. The data are equivalent to the official (all elements complete ring) file except that the bending magnet has been replaced by its model as defined by H. Kugler (3). Moreover the monitors (see below) were defined with "Type-PUE" in the MAD data as required by ORBCOR.

b) Corrector file

Two files, one horizontal (fig. 1A), one vertical (fig 1b).
For the vertical file: the center of each quadrupole taken at the end of the first half of the quadrupole defined as HR.QxxxxH (for upstream)
For the horizontal file: the centre of each quadrupole plus the horizontal bumpers HR.BSWxx
(for orbit correction, only the quadrupole displacement will be used and the bumpers will be disabled)
(for orbit bump, only the bumpers will be used and the quadrupoles will be disabled).

For each element, the maximum displacement ± 3mm (or current ± 83 Amp) is introduced as well as the calibration factor as defined above.

Therefore, the results will be directly accessible in displacement for the quadrupoles and in current for the bumpers.

c) Orbit file (figure 2)

All the 20 beam position monitors are introduced including the special HR.UMA62 which can be disabled if this monitor is reserved for intensity measurement only.

4. Test of Option CALC

This option calculates the closed orbit distortion due to localized kicks. In order to check it, a known deflection angle is introduced in (i) one then (ii) two corretors and the results compared with analytical calculation.

The corresponding closed orbit deformation can be seen on:

(i) (figure 3a): 1 mrad in HR.QFN62

(ii) (figure 3b): 1 mrad in HR.QFW02 plus 0.05 mrad in HR.QFI22

5. Test of Closed Orbit Correction (option GLBL)

This option picks the most effective N correctors and calculates then the corresponding deflection angles to correct a given closed orbit deviation. Using the above two orbits, with a correction performed by N = 1 or 2 correctors, ORBCOR suggested:

in case (i):

- using one corrector only (figure 4a) HRQFN62 was found as the the most effective corrector with the right correction angle.
- using two correctors (figure 4b), the second one has a small strength

in case (ii):

- using one corrector only (figure 5a), as expected the most effective corrector was found to be HR.QFW02 with $\theta = -1.23$ mrad.
- using two correctors (figure 5b), the two original correctors are also effectively found with the right correction angle.

Remark: In each case, the beam is found to be off momentum by -1.7×10^{-4}, which corresponds to the orbit length increase by betatron oscillation.

6. Test of local bump (option LOCAL)

This option uses 4 correctors to produce a desired local bump of x, x' at a desired position. This could be very useful for EPA to calculate the required strength in the 4 bump magnets to produce the injection and extraction bumps.

In order to force the program to effectively use the 4 bumpers, all the quadrupole correctors are first disabled. The desired bump at the extraction septum HR.SMHØØ of x = + 50 mm   x' = 0.0 mrad was actually reached from

- an ideal closed orbit (figure 6a)
- a distorted closed orbit (figure 6b)

In each case because of the π phase advance between bumpers 12 - 32 and 71 - 91 in the EPA lattice, the bumpers are fighting one against the other and their corresponding strengths for a precise local bump reach very high values.

Nevertheless, a very small change in phase advance between bumpers ($\Delta\mu$ =0.001) allowed an easy and perfect solution (figure 7).

7. Conclusion

The ORBCOR program has been shown to be easily adaptable to the characteristics of the EPA machine (closed orbit correction by mechanical displacement of the main lattice quadrupoles) and to give confident results with an easy and user-friendly access.

Although an on-line analysis is not abslutely necessary, the ORBCOR program as implemented in the PRDEV can be an excellent candidate for the EPA closed orbit correction as it could also be used:

- for the local bump adjustment taking into account the actually measured closed orbit,
- for circulating beam energy determination,
- for operational orbit comparison (difference orbit),
- for orbit perturbation analysis as an excellent diagnostic for ring modelling and debugging (4).

Moreover the trajectory correction option could serve as the basis for LIL beam characteristics measurements at EPA injection (energy and steering) and help for the steering of LIL and transfer lines.

Nevertheless, the results should be compared with the PETROC program results and capability (coupling, for example) as the simulation program used until now by H. Kugler. Finally, the use of the ORBCOR program could be greatly facilitated by an easy transfer of the beam position measurement from the console to the PRDEV.

References

[1] E. Bozoki, Status and Options of the ORBIT correction program, CERN/PS/PSR 85-57.

[2] E. Bozoki, J.P. Potier, T. Risselada, First tests of ORBCOR PS/ML 85-9

[3] M. Bell, H. Kugler, Modellisation of the EPA bending magnet: to be published.

[4] J. Jaeger, M. Lee, M. Woodley, J.P. Delahaye, Modelling of the SLC electron damping ring; SLAC-PUB 3408.

[5] F. Perriollat, Modelling - communication on protocol console-ND500, PS/CO/Note 85-006.

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MAGNET	POWER SUPPLY	D/E	DMAX	DCUR	CALFACT
HRQFW02U	HRQFW02	0	30.00	.0	0.841461
HRQTR03U	HRQTR03	0	30.00	.0	-0.063099
HRQFL04U	HRQFL04	0	30.00	.0	1.042985
HRQFL06U	HRQFL06	0	30.00	.0	1.042985
HRQTR07U	HRQTR07	0	30.00	.0	-0.063099
HRQFW08U	HRQFW08	0	30.00	.0	0.841461
HRQFN12U	HRQFN12	0	30.00	.0	0.405481
HRBSW12U	HRBSW12	0	8.3	.0	0.001
HRQDN12U	HRQDN12	0	30.00	.0	-0.407632
HRQDN14U	HRQDN14	0	30.00	.0	-0.407632
HRQFI14U	HRQFI14	0	30.00	.0	0.405779
HRQFI22U	HRQFI22	0	30.00	.0	0.405779
HRQDN22U	HRQDN22	0	30.00	.0	-0.407632
HRQDN24U	HRQDN24	0	30.00	.0	-0.407632
HRQFN24U	HRQFN24	0	30.00	.0	0.405481
HRQFN32U	HRQFN32	0	30.00	.0	0.405481
HRBSW32U	HRBSW32	0	8.3	.0	0.001
HRQDN34U	HRQDN34	0	30.00	.0	-0.407632
HRQFN34U	HRQFN34	0	30.00	.0	0.405481
HRQFW42U	HRQFW42	0	30.00	.0	0.841461
HRQTR43U	HRQTR43	0	30.00	.0	-0.063099
HRQFL44U	HRQFL44	0	30.00	.0	1.042985
HRQFL46U	HRQFL46	0	30.00	.0	1.042985
HRQTR47U	HRQTR47	0	30.00	.0	-0.063099
HRQFW48U	HRQFW48	0	30.00	.0	0.841461
HRQFW52U	HRQFW52	0	30.00	.0	0.841461
HRQTR53U	HRQTR53	0	30.00	.0	-0.063099
HRQFL54U	HRQFL54	0	30.00	.0	1.042985
HRQFL56U	HRQFL56	0	30.00	.0	1.042985
HRQTR57U	HRQTR57	0	30.00	.0	-0.063099
HRQFW58U	HRQFW58	0	30.00	.0	0.841461
HRQFN62U	HRQFN62	0	30.00	.0	0.405481
HRQDN62U	HRQDN62	0	30.00	.0	-0.407632
HRQDN64U	HRQDN64	0	30.00	.0	-0.407632
HRQFN64U	HRQFN64	0	30.00	.0	0.405481
HRBSW71U	HRBSW71	0	8.3	.0	0.001
HRQFN72U	HRQFN72	0	30.00	.0	0.405481
HRQDN72U	HRQDN72	0	30.00	.0	-0.407632
HRQDN74U	HRQDN74	0	30.00	.0	-0.407632
HRQFI74U	HRQFI74	0	30.00	.0	0.405779
HRQFI82U	HRQFI82	0	30.00	.0	0.405779
HRQDN82U	HRQDN82	0	30.00	.0	-0.407632
HRQDN84U	HRQDN84	0	30.00	.0	-0.407632
HRQFN84U	HRQFN84	0	30.00	.0	0.405481
HRBSW91U	HRBSW91	0	8.3	.0	0.001
HRQFW92U	HRQFW92	0	30.00	.0	0.841461
HRQTR93U	HRQTR93	0	30.00	.0	-0.063099
HRQFL94U	HRQFL94	0	30.00	.0	1.042985
HRQFL96U	HRQFL96	0	30.00	.0	1.042985
HRQTR97U	HRQTR97	0	30.00	.0	-0.063099
HRQFW98U	HRQFW98	0	30.00	.0	0.841461

a) Horizontal plane

MAGNET	POWER SUPPLY	D/E	DMAX	DCUR	CALFACT
HRQFW02U	HRQFW02	0	30.00	.0	0.841461
HRQTR03U	HRQTR03	0	30.00	.0	-0.063099
HRQFL04U	HRQFL04	0	30.00	.0	1.042985
HRQFL06U	HRQFL06	0	30.00	.0	1.042985
HRQTR07U	HRQTR07	0	30.00	.0	-0.063099
HRQFW08U	HRQFW08	0	30.00	.0	0.841461
HRQFN12U	HRQFN12	0	30.00	.0	0.405481
HRQDN12U	HRQDN12	0	30.00	.0	-0.407632
HRQDN14U	HRQDN14	0	30.00	.0	-0.407632
HRQFI14U	HRQFI14	0	30.00	.0	0.405779
HRQFI22U	HRQFI22	0	30.00	.0	0.405779
HRQDN22U	HRQDN22	0	30.00	.0	-0.407632
HRQDN24U	HRQDN24	0	30.00	.0	-0.407632
HRQFN24U	HRQFN24	0	30.00	.0	0.405481
HRQFN32U	HRQFN32	0	30.00	.0	0.405481
HRQDN34U	HRQDN34	0	30.00	.0	-0.407632
HRQFN34U	HRQFN34	0	30.00	.0	0.405481
HRQFW42U	HRQFW42	0	30.00	.0	0.841461
HRQTR43U	HRQTR43	0	30.00	.0	-0.063099
HRQFL44U	HRQFL44	0	30.00	.0	1.042985
HRQFL46U	HRQFL46	0	30.00	.0	1.042985
HRQTR47U	HRQTR47	0	30.00	.0	-0.063099
HRQFW48U	HRQFW48	0	30.00	.0	0.841461
HRQFW52U	HRQFW52	0	30.00	.0	0.841461
HRQTR53U	HRQTR53	0	30.00	.0	-0.063099
HRQFL54U	HRQFL54	0	30.00	.0	1.042985
HRQFL56U	HRQFL56	0	30.00	.0	1.042985
HRQTR57U	HRQTR57	0	30.00	.0	-0.063099
HRQFW58U	HRQFW58	0	30.00	.0	0.841461
HRQFN62U	HRQFN62	0	30.00	.0	0.405481
HRQDN62U	HRQDN62	0	30.00	.0	-0.407632
HRQDN64U	HRQDN64	0	30.00	.0	-0.407632
HRQFN64U	HRQFN64	0	30.00	.0	0.405481
HRQFN72U	HRQFN72	0	30.00	.0	0.405481
HRQDN72U	HRQDN72	0	30.00	.0	-0.407632
HRQDN74U	HRQDN74	0	30.00	.0	-0.407632
HRQFI74U	HRQFI74	0	30.00	.0	0.405779
HRQFI82U	HRQFI82	0	30.00	.0	0.405779
HRQDN82U	HRQDN82	0	30.00	.0	-0.407632
HRQDN84U	HRQDN84	0	30.00	.0	-0.407632
HRQFN84U	HRQFN84	0	30.00	.0	0.405481
HRQFW92U	HRQFW92	0	30.00	.0	0.841461
HRQTR93U	HRQTR93	0	30.00	.0	-0.063099
HRQFL94U	HRQFL94	0	30.00	.0	1.042985
HRQFL96U	HRQFL96	0	30.00	.0	1.042985
HRQTR97U	HRQTR97	0	30.00	.0	-0.063099
HRQFW98U	HRQFW98	0	30.00	.0	0.841461

b) Vertical plane

fig 1 : Corrector files

H-CO	V-CO	E/D	PU.NAME
.0	.0	0	HRSMH000
.00000	.00000	0	HRUMA03U
.00000	.00000	0	HRUMA05U
.00000	.00000	0	HRUMA11U
.00000	.00000	0	HRUMA13U
.00000	.00000	0	HRUMA23U
.00000	.00000	0	HRUMA33U
.00000	.00000	0	HRUMA41U
.00000	.00000	0	HRUMA45U
.00000	.00000	0	HRUMA47U
.00000	.00000	0	HRUMA49U
.00000	.00000	0	HRUMA53U
.00000	.00000	0	HRUMA55U
.00000	.00000	0	HRUMA61U
.00000	.00000	0	HRUMA62U
.00000	.00000	0	HRUMA63U
.00000	.00000	0	HRUMA73U
.00000	.00000	0	HRUMA83U
.00000	.00000	0	HRUMA91U
.00000	.00000	0	HRUMA95U
.00000	.00000	0	HRUMA97U

END

fig 2: Orbit file

```
                                        MEASURED         IMPLEMENT
RING= EPA      MOMENTUM [Gev/c]=         .6000             .6000
Q =    4.460  IXY(1/HOR  2/VERT)=HOR    CORRECTION TYPE =CALC
ITER=  1        IRESET= 0


CALCULATED ORBIT [mm]:                                           (NPUE= 21)
   -.08  -1.73  -2.44   6.72   2.10  -2.59  -2.83    .85   2.99  -1.86
  -7.02  -2.30   2.36   2.58   1.39   2.82   2.60  -2.09  -6.74   2.43
   1.75

      CORRECTOR              STRENGTH
       #  NAME                [mrad]
      32  HRQFN62U            1.000
```

fig 3a

```
                                        MEASURED         IMPLEMENT
RING= EPA      MOMENTUM [Gev/c]=         .6000             .6000
Q =    4.460  IXY(1/HOR  2/VERT)=HOR    CORRECTION TYPE =CALC
ITER=  2        IRESET= 0


CALCULATED ORBIT [mm]:                                           (NPUE= 21)
   2.76    .91   1.39  -3.66  -1.20   3.94   4.40  -1.15  -4.65   2.83
  10.79   3.58  -3.58  -4.13    .22   3.48   4.72  -2.06 -10.71   2.51
   3.45

      CORRECTOR              STRENGTH
       #  NAME                [mrad]
       1  HRQFW02U            1.000
      12  HRQFI22U             .500
```

fig 3b

fig 3: Calculated orbit deformation with (a) 1 or (b) 2 perturbating elements.

```
                                      MEASURED       IMPLEMENT
RING= EPA     MOMENTUM [Gev/c]=        .6000          .6000
Q =   4.460  IXY(1/HOR  2/VERT)=HOR    CORRECTION TYPE =GLBL
ITER=  1      IRESET= 0
```

THE 1 CORRECTORS CHOSEN FOR ORBIT CORRECTION:

CORRECTOR SEQ-#	NAME	STRENGTH BEFORE CORR.	STRENGTH [mrad] AFTER CORR.	POWER SUPPLY	[Amp] AFTER
32	HRQFN62U	.0000	-.9808	HRQFN62	-.00484

READINGS ON THE 21 POSITION MONITORS:

NEW SEQ-#	NAME	BEFORE CORR.	AFTER CORR. [mm]
1	HRSMH00D	-.0755	-.0014
2	HRUMA03U	-1.7343	-.0332
3	HRUMA05U	-2.4436	-.0468
4	HRUMA11U	6.7239	.1288
5	HRUMA13U	2.1035	.0403
6	HRUMA23U	-2.5876	-.0496
7	HRUMA33U	-2.8306	-.0542
8	HRUMA41U	.8535	.0163
9	HRUMA45U	2.9869	.0572
10	HRUMA47U	-1.8646	-.0357
11	HRUMA49U	-7.0161	-.1344
12	HRUMA53U	-2.3035	-.0441
13	HRUMA55U	2.3635	.0453
14	HRUMA61U	2.5843	.0495
15	HRUMA62U	1.3885	.0266
16	HRUMA63U	2.8226	.0541
17	HRUMA73U	2.5975	.0498
18	HRUMA83U	-2.0898	-.0400
19	HRUMA91U	-6.7356	-.1290
20	HRUMA95U	2.4288	.0465
21	HRUMA97U	1.7470	.0335
	***	RMS 3.2992	.0632

BEAM IS OFF MOMENTUM BY dP/P= .00044

fig 4 a

```
                                      MEASURED       IMPLEMENT
RING= EPA     MOMENTUM [Gev/c]=        .6000          .6000
Q =   4.460  IXY(1/HOR  2/VERT)=HOR    CORRECTION TYPE =GLBL
ITER=  2      IRESET= 0
```

THE 2 CORRECTORS CHOSEN FOR ORBIT CORRECTION:

CORRECTOR SEQ-#	NAME	STRENGTH BEFORE CORR.	STRENGTH [mrad] AFTER CORR.	POWER SUPPLY	[Amp] AFTER
32	HRQFN62U	.0000	-.9723	HRQFN62	-.00480
20	HRQFW42U	.0000	.0321	HRQFW42	.00008

READINGS ON THE 21 POSITION MONITORS:

NEW SEQ-#	NAME	BEFORE CORR.	AFTER CORR. [mm]
1	HRSMH00D	-.0755	-.0650
2	HRUMA03U	-1.7343	-.0133
3	HRUMA05U	-2.4436	.0333
4	HRUMA11U	6.7239	-.0074
5	HRUMA13U	2.1035	-.0311
6	HRUMA23U	-2.5876	-.0104
7	HRUMA33U	-2.8306	.0260
8	HRUMA41U	.8535	.0605
9	HRUMA45U	2.9869	.1824
10	HRUMA47U	-1.8646	-.1101
11	HRUMA49U	-7.0161	-.4217
12	HRUMA53U	-2.3035	-.1405
13	HRUMA55U	2.3635	.1393
14	HRUMA61U	2.5843	.1631
15	HRUMA62U	1.3885	.0369
16	HRUMA63U	2.8226	.0063
17	HRUMA73U	2.5975	-.0285
18	HRUMA83U	-2.0898	-.0165
19	HRUMA91U	-6.7356	.0394
20	HRUMA95U	2.4288	.0164
21	HRUMA97U	1.7470	-.0255
	***	RMS 3.2992	.1205

BEAM IS OFF MOMENTUM BY dP/P= .00044

fig 4 b

fig 4 : Correction of a closed orbit perturbed by 1 mrad in HR.QFN62 and using 1 (a) or 2 (b) correctors.

fig 5 a

RING= EPA MOMENTUM [GEV/C]= MEASURED .6000 IMPLEMENT .6000
Q = 4.460 IXY(1/HOR 2/VERT)=HOR CORRECTION TYPE =GLBL
ITER= 1 IRESET= 0

THE 1 CORRECTORS CHOSEN FOR ORBIT CORRECTION:

CORRECTOR SEQ-#	NAME	STRENGTH BEFORE CORR.	STRENGTH [MRAD] AFTER CORR.	POWER SUPPLY	[AMP] AFTER
1	HRQFW02U	.0000	-1.2282	HRQFW02	-.00292

READINGS ON THE 20 POSITION MONITORS:

NEW SEQ-#	NAME	BEFORE CORR.	AFTER CORR. [MM]
1	HRUMA03U	.9126	-1.0965
2	HRUMA05U	1.3913	-2.0207
3	HRUMA11U	-3.6575	4.7892
4	HRUMA13U	-1.2026	1.7615
5	HRUMA23U	3.9381	.8358
6	HRUMA33U	4.4028	.5913
7	HRUMA41U	-1.1542	-.7682
8	HRUMA45U	-4.6513	-.6060
9	HRUMA47U	2.8268	.6397
10	HRUMA49U	10.7810	1.8906
11	HRUMA53U	3.5837	.4785
12	HRUMA55U	-3.5777	-.8292
13	HRUMA61U	-4.1331	-.1541
14	HRUMA62U	.2239	.4323
15	HRUMA63U	3.4805	.7836
16	HRUMA73U	4.7158	.6735
17	HRUMA83U	-2.0558	-.5966
18	HRUMA91U	-10.7093	-1.7943
19	HRUMA95U	2.5133	.6894
20	HRUMA97U	3.4502	.4442
	***	RMS 4.5494	1.4791

BEAM IS OFF MOMENTUM BY DP/P= -.00017

fig 5 b

RING= EPA MOMENTUM [GEV/C]= MEASURED .6000 IMPLEMENT .6000
Q = 4.460 IXY(1/HOR 2/VERT)=HOR CORRECTION TYPE =GLBL
ITER= 2 IRESET= 0

THE 2 CORRECTORS CHOSEN FOR ORBIT CORRECTION:

CORRECTOR SEQ-#	NAME	STRENGTH BEFORE CORR.	STRENGTH [MRAD] AFTER CORR.	POWER SUPPLY	[AMP] AFTER
1	HRQFW02U	.0000	-1.0067	HRQFW02	-.00239
11	HRQFI22U	.0000	-.4381	HRQFI22	-.00241

READINGS ON THE 20 POSITION MONITORS:

NEW SEQ-#	NAME	BEFORE CORR.	AFTER CORR. [MM]
1	HRUMA03U	.9126	-.0282
2	HRUMA05U	1.3913	-.0517
3	HRUMA11U	-3.6575	.1230
4	HRUMA13U	-1.2026	.0451
5	HRUMA23U	3.9381	.0168
6	HRUMA33U	4.4028	.0102
7	HRUMA41U	-1.1542	-.0180
8	HRUMA45U	-4.6513	-.0104
9	HRUMA47U	2.8268	.0131
10	HRUMA49U	10.7810	.0361
11	HRUMA53U	3.5837	.0083
12	HRUMA55U	-3.5777	-.0170
13	HRUMA61U	-4.1331	.0004
14	HRUMA62U	.2239	.0105
15	HRUMA63U	3.4805	.0160
16	HRUMA73U	4.7158	.0120
17	HRUMA83U	-2.0559	-.0128
18	HRUMA91U	-10.7093	-.0338
19	HRUMA95U	2.5133	.0145
20	HRUMA97U	3.4502	.0076
	***	RMS 4.5494	.0356

BEAM IS OFF MOMENTUM BY DP/P= -.00017

fig 5: Correction of a closed orbit perturbed by 1 mrad in HR.QFW02 and 0.5 mrad in HR.QFI22 and using 1 (a) or 2 (b) correctors.

fig 6 a

```
                         MEASURED       IMPLEMENT
RING= EPA   MOMENTUM [GEV/C]=  .6000       .6000
Q =   4.460  IXY(1/HOR  2/VERT)=HOR   CORRECTION TYPE =LOCL

LOCL BUMP AT HRSMHOOD (BETA= .1471E+02   PHI= .2245E-02   DISP= .4944E-06)
  DESIRED   XY0= 50.00 [MM]     XYP0=    .00 [MRAD]
  PRESENT          .00                   .00
```

THE 4 CORRECTORS CHOSEN FOR ORBIT CORRECTION:

CORRECTOR SEQ-#	NAME	STRENGTH BEFORE CORR.	STRENGTH [MRAD] AFTER CORR.	POWER SUPPLY	[AMP] AFTER
50	HRBSW71U	.0000	5365.0928	HRBSW71	10.73748
51	HRBSW91U	.0000	5362.0059	HRBSW91	10.73130
48	HRBSW12U	.0000	-9063.3867	HRBSW12	-18.13910
49	HRBSW32U	.0000	-9059.4863	HRBSW32	-18.13129

READINGS ON THE 20 POSITION MONITORS:

NEW SEQ-#	NAME	BEFORE CORR.	AFTER CORR. [MM]
1	HRUMA03U	.0000	14.1367
2	HRUMA05U	.0000	-17.5156
3	HRUMA11U	.0000	-12.3633
4	HRUMA13U	.0000	-40849.8438
5	HRUMA23U	.0000	-36374.3359
6	HRUMA33U	.0000	.8828
7	HRUMA41U	.0000	3.0156
8	HRUMA45U	.0000	-1.0586
9	HRUMA47U	.0000	-.8359
10	HRUMA49U	.0000	-.1724
11	HRUMA53U	.0000	.7383
12	HRUMA55U	.0000	1.1758
13	HRUMA61U	.0000	-2.9688
14	HRUMA62U	.0000	-2.0781
15	HRUMA63U	.0000	-1.0234
16	HRUMA73U	.0000	21753.0469
17	HRUMA83U	.0000	28397.1602
18	HRUMA91U	.0000	-10.4893
19	HRUMA95U	.0000	-18.1523
20	HRUMA97U	.0000	13.6816

fig 6 b

```
                         MEASURED       IMPLEMENT
RING= EPA   MOMENTUM [GEV/C]=  .6000       .6000
Q =   4.460  IXY(1/HOR  2/VERT)=HOR   CORRECTION TYPE =LOCL

LOCL BUMP AT HRSMHOOD (BETA= .1471E+02   PHI= .2245E-02   DISP= .4944E-06)
  DESIRED   XY0= 50.00 [MM]     XYP0=    .00 [MRAD]
  PRESENT         7.28                  -.36
```

THE 4 CORRECTORS CHOSEN FOR ORBIT CORRECTION:

CORRECTOR SEQ-#	NAME	STRENGTH BEFORE CORR.	STRENGTH [MRAD] AFTER CORR.	POWER SUPPLY	[AMP] AFTER
50	HRBSW71U	.0000	-26867.0781*** CORR.MAX.STRENGTH EXCEEDED, REPLACED		
51	HRBSW91U	.0000	-26871.2930*** CORR.MAX.STRENGTH EXCEEDED, REPLACED		
48	HRBSW12U	.0000	24393.0000*** CORR.MAX.STRENGTH EXCEEDED, REPLACED		
49	HRBSW32U	.0000	24396.3320*** CORR.MAX.STRENGTH EXCEEDED, REPLACED		

READINGS ON THE 20 POSITION MONITORS:

NEW SEQ-#	NAME	BEFORE CORR.	AFTER CORR. [MM]
1	HRUMA03U	.9126	17.1172
2	HRUMA05U	1.3913	-16.2734
3	HRUMA11U	-3.6575	-21.1172
4	HRUMA13U	-1.2026	110003.5000
5	HRUMA23U	3.9381	97956.5937
6	HRUMA33U	4.4028	2.0391
7	HRUMA41U	-1.1542	-9.3125
8	HRUMA45U	-4.6513	-1.8203
9	HRUMA47U	2.8268	5.0859
10	HRUMA49U	10.7810	11.1582
11	HRUMA53U	3.5837	1.5703
12	HRUMA55U	-3.5777	-6.8203
13	HRUMA61U	-4.1331	3.9063
14	HRUMA62U	.2239	5.8750
15	HRUMA63U	3.4805	6.2891
16	HRUMA73U	4.7158	-108927.5000
17	HRUMA83U	-2.0558	-142205.1562
18	HRUMA91U	-10.7093	-18.5937
19	HRUMA95U	2.5133	-18.7031
20	HRUMA97U	3.4502	17.3984

<u>fig 6:</u> Local orbit bump deformation from an ideal (a) or distorted (b) closed orbit.

	MEASURED	IMPLEMENT
NG= EPA MOMENTUM [Gev/c]=	.6000	.6000

Q = 4.460 IXY(1/HOR 2/VERT)=HOR CORRECTION TYPE =LOCL

LOCL BUMP AT HRSMHOOD (BETA= .1471E+02 PHI= .2245E-02 DISP= .4944E-06)

		XYO=	XYPO=
DESIRED		5.00 [mm]	.00 [mrad]
PRESENT		.00	.00

THE 4 CORRECTORS CHOSEN FOR ORBIT CORRECTION:

SEQ-#	CORRECTOR NAME	STRENGTH BEFORE CORR.	STRENGTH [mrad] AFTER CORR.	POWER SUPPLY	[Amp] AFTER
36	HRBSW71U	.0000	-1.0083	HRBSW71	-2.01801
45	HRBSW91U	.0000	-1.3612	HRBSW91	-2.72424
8	HRBSW12U	.0000	1.4496	HRBSW12	2.90111
17	HRBSW32U	.0000	1.8395	HRBSW32	3.68143

READINGS ON THE 21 POSITION MONITORS:

NEW SEQ-#	NAME	BEFORE CORR.	AFTER CORR. [mm]
1	HRSMHOOD	.0000	5.0000
2	HRUMA03U	.0000	1.4965
3	HRUMA05U	.0000	-1.8803
4	HRUMA11U	.0000	-1.2888
5	HRUMA13U	.0000	8.3400
6	HRUMA23U	.0000	7.3329
7	HRUMA33U	.0000	.0000
8	HRUMA41U	.0000	.0000
9	HRUMA45U	.0000	.0000
10	HRUMA47U	.0000	.0000
11	HRUMA49U	.0000	.0000
12	HRUMA53U	.0000	.0000
13	HRUMA55U	.0000	.0000
14	HRUMA61U	.0000	.0000
15	HRUMA62U	.0000	.0000
16	HRUMA63U	.0000	.0000
17	HRUMA73U	.0000	-4.0544
18	HRUMA83U	.0000	-5.3621
19	HRUMA91U	.0000	-1.1569
20	HRUMA95U	.0000	-1.9258
21	HRUMA97U	.0000	1.4686

fig 7: Local orbit bump deformation after a $\Delta\mu = 0.001$ phase advance change between bumpers.