

Lattice Analysis

H. Koiso

KEKB Accelerator Review
Committee Meeting

March 8, 1999

Lattice for commissioning

Lattice for BEAST

- Almost same as that for Belle
- No detector solenoid
- 10 % excitation of compensation solenoid
- Make local bumps to adjust orbit and dispersion in IR

Relaxed β^* ($\beta^*x = 1$ m, $\beta^*y = 0.02$ m)

- Possible to decrease β^*y to 0.008 m by adjusting only 12 quadrupoles in the tuning sections

Chromaticity correction

- Noninterleaved 56-family correction
- Local correction in IR only for LER (vertical direction)

Wigglers in LER

- installed but not used

Energy (dipole field)

- Adjusted to match BT line.
- Nominal values were determined so as to minimize synchrotron oscillation observed by single pass monitor.

Closed Orbit

- Global closed orbit -- Successfully corrected with conventional method (SVD or MICAD) to less than 1 mm rms.
- Local bump -- Used in fine tuning of orbit (in particular in IR) and diagnostics of machine errors.

Transverse tune

- Even after a few steps of improvement, there are still some deviations from model in both rings (largest in LER vertical tune).
- Need precise calibration between various magnet to identify error sources.

Dispersion

- Peak values of horizontal dispersion agree with model within 16% in LER and 6% in HER, assuming design α .
- Sometimes large vertical dispersion was observed.
- So far, not yet tried dispersion correction.

Chromaticity

- Not so big deviation from model .
- Necessary to adjust tunes of model lattice to measured ones in finding solution of sextupole strength.

β function

- Big mismatch of LER vertical optics was observed in response of single kick orbit and in measurement with trim coil of each quadrupole
- Matching was almost recovered by adjusting QCS strength of +0.8 %
- Vertical β functions at QC1L/RE and QC3LE agree with model in HER

Emittance / XY coupling

- Reduced vertical beam size by tuning bumps at sextupoles (reduced coupling to 20% in HER).
- Measured tune split at coupling resonance.
- Measured bump response around IP.

Beam-based measurement of BPM offset (Quad-BPM measurement)

- Measured for several BPMs in IR and helped us to find inconsistency of BPM readings.

Strength deviation of quadrupoles

- Partly checked with local bump.
- Computing tools are being developed to determine strength errors from single kick response and from globally measured β function.

Next steps

Reduce β^*y to 1 cm.

Reduce vertical emittance by bump tuning, xy coupling correction by skew quadrupoles etc.

Precise measurement of strength errors of quadrupoles by local bump to find sources of tune difference.

Measure BPM offset by quad-BPM method.

Measure sextupole offset with local bump, movers, K-modulation.

KEKB Ring Optics

Name: 241_B99C

Convergence .00000

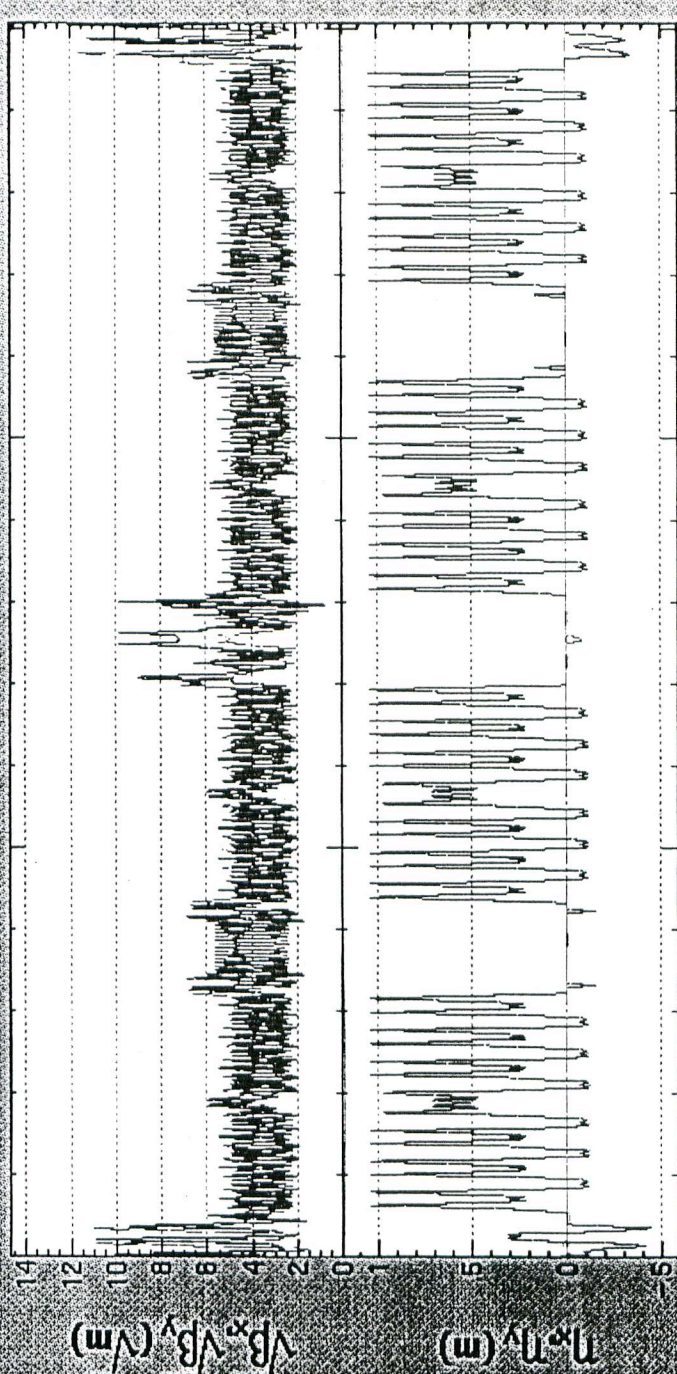
$V_x = 45.63000$ $V_y = 44.36000$
 $\beta_x = 1.00051$ $\beta_y = .02001$

- Ring
- Normal Optics
- Wigner
- Chronologically
- Map

Display All Ring

$c_0 = 1.7723465E-8$ m
 $c_1 = 6.344165E-10$ m
 $c_2 = 2.7665940E-6$ m
 $\alpha = 1.7170160E-4$
 $c_3 = 3.79404$ mm
 $\delta p/p_0 = 7.2514655E-4$
 $U_1 = 336211$ MV
 $\delta V/V_0 = .032327$

Calculate emittance



0 1000 2000 3000

- QKRRP
- QL1RP
- QASRP
- QEAP 47
- QD3P 39
- QD3P 36
- QD5P 44
- QD1P 22
- QF5OP
- QD1P 21
- QD5P 41
- QD3P 33
- QD3P 32
- QD5P 38
- QW7OP 2
- QW2OP 2
- QFWOP 4
- QDWOP 2
- QW4OP 1
- QS2OP 1
- QD3P 30
- QD5P 34
- QD1P 17
- QEAP 31
- QT1FOP 2
- QTAOP 1
- QD3P 25
- QD3P 24
- QD5P 28
- QD1P 13
- QD5P 25
- QI6P
- QFRP 3
- QV1P 2
- QFRP 2
- QR4P
- QD5P 24
- QF2P 23
- QEAP 21
- QF4P 17
- QD3P 16
- QT3NFP 2
- QT1NFP 1
- QD5P 16
- QD1P 8
- QD5P 15
- QD3P 11
- QS8NP 2
- QW4NP 2
- QDWNP 5
- QFWNP 2
- QW2NP 1
- QW6NP 1
- QEAP 11
- QD3P 9
- QD3P 8
- QD5P 8
- QD1P 4
- QTSNP
- QD1P 3
- QD5P 5
- QD3P 3
- QD3P 2
- QD5P 2
- QA5LP
- QL2LP 2
- QC3LP
- QC6LP 14

BEAST

HER LER

Save Optics

KEKB Ring Optics

Name: 24FEB99C

Convergence = 3.4684E-6

$V_x = 45.63000$ $V_y = 44.36000$
 $\beta_x = 1.00051$ $\beta_y = .02001$ m

IR

Name Lists

Wigner

Chromatically

Mapmat

Display IR

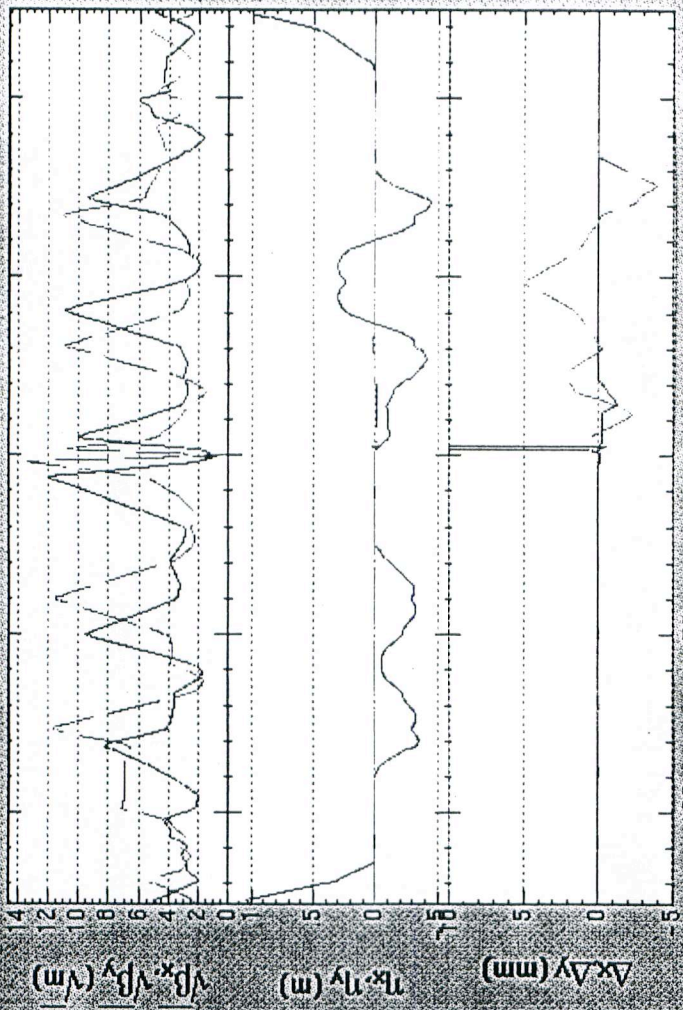
β_x	-1.485E-4	.00000
β_y	-3.055E-4	.00000
β_z (m)	1.00051	1.00000
β_x (m)	.02001	.02000
β_y @ CAR (m)	18.73280	100.00000
β_x @ CAR (m)	45.93979	120.00000
β_y @ CAR (m)	35.92682	100.00000
β_x @ MC (m)	23.94741	120.00000

Match match tune together

Back

History

Convergence = 3.4684E-6



- Q52TRF
- Q53TRF
- Q54TRF
- Q55TRF
- Q56TRF
- Q57TRF
- Q58TRF
- Q59TRF
- Q60TRF
- Q61TRF
- Q62TRF
- Q63TRF
- Q64TRF
- Q65TRF
- Q66TRF
- Q67TRF
- Q68TRF
- Q69TRF
- Q70TRF
- Q71TRF
- Q72TRF
- Q73TRF
- Q74TRF
- Q75TRF
- Q76TRF
- Q77TRF
- Q78TRF
- Q79TRF
- Q80TRF
- Q81TRF
- Q82TRF
- Q83TRF
- Q84TRF
- Q85TRF
- Q86TRF
- Q87TRF
- Q88TRF
- Q89TRF
- Q90TRF
- Q91TRF
- Q92TRF
- Q93TRF
- Q94TRF
- Q95TRF
- Q96TRF
- Q97TRF
- Q98TRF
- Q99TRF
- Q100TRF

Save Optics

HER LER

BEAST

KEKB Ring Optics

Name: Temp02_24_1999_08:13:26

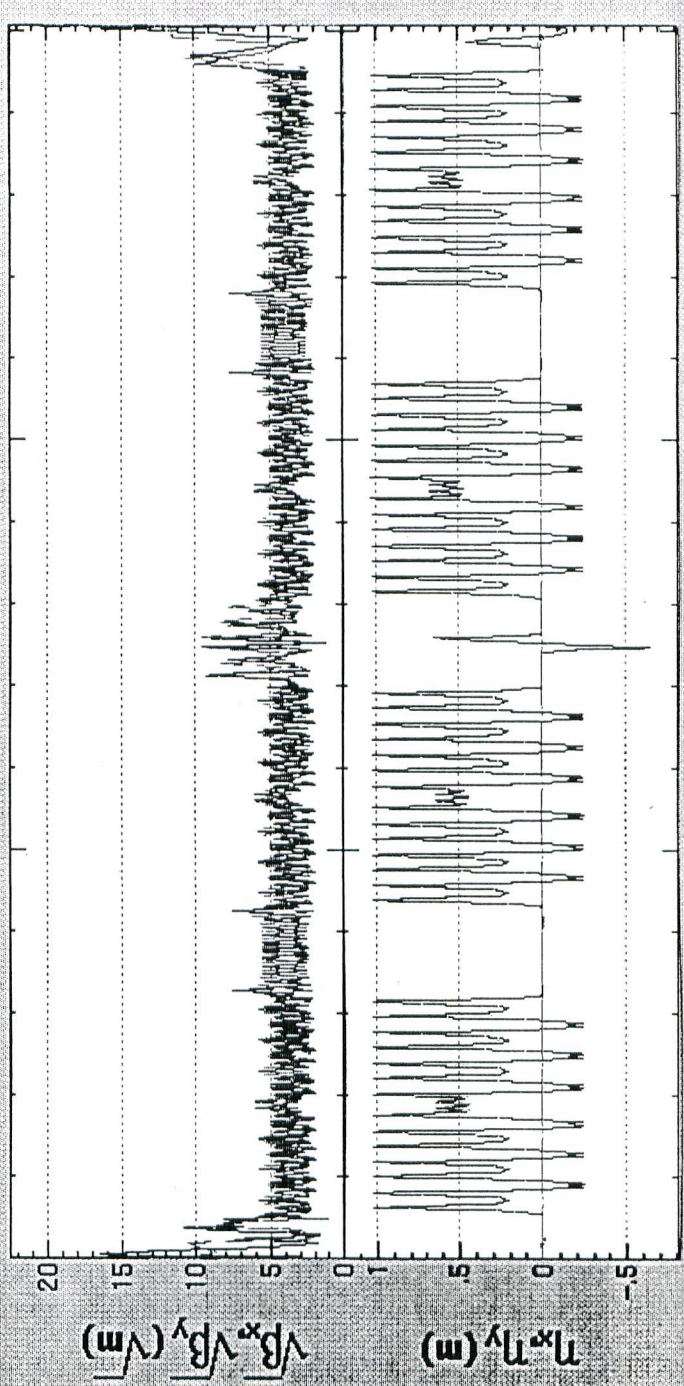
Convergence = .01579 $V_x^* = 44.50700$ $V_y^* = 42.26500$
 $\beta_x^* = .99995$ $\beta_y^* = .02002$ m

- Ring
- Tune Adjust
- IR
- Normal Cells
- RF
- Chromaticity
- Magnet

Display All Ring

$c_1 = 1.7001776E-8$ m
 $c_2 = 1.191101E-13$ m
 $c_3 = 3.3572871E-6$ m
 $\alpha = 1.0797913E-4$
 $\alpha_z = 5.036566$ mm
 $\delta p/p_0 = 6.6559203E-4$
 $U_0 = 3.467304$ MV
 $\delta V/p_0 = .017001$

Calculate emittance



- QKARE
- QKERE
- QS2IRE
- QD5E.47
- QF4E.39
- QD3E.38
- QD5E.44
- QD4E.22
- QF50IE
- QD4E.21
- QD5E.41
- QD3E.33
- QD3E.32
- QD5E.38
- QR70E.2
- QR30E.2
- QFROE.4
- QDROE.2
- QR40E.1
- QSB0E.1
- QD3E.30
- QD5E.34
- QD1E.17
- QD5E.31
- QT1FOE.2
- QT4FOE.1
- QD3E.25
- QD3E.24
- QD5E.28
- QD1E.13
- QR6E.13
- QM6E
- QX7E.2
- QX2E.2
- QX6E.1
- QI5E
- QD5E.24
- QD1E.12
- QD5E.21
- QD3E.17
- QD3E.16
- QT3NFE.2
- QT1NFE.1
- QD5E.18
- QD1E.8
- QD5E.15
- QD3E.11
- QSBNE.2
- QR4NE.2
- QDRNE.5
- QDRNE.3
- QR2NE.1
- QR7NE.1
- QD5E.11
- QD3E.9
- QD3E.8
- QD5E.8
- QD1E.4
- QF50IE
- QD1E.3
- QD5E.5
- QD3E.2
- QD3E.2
- QD5E.2
- QS2ILE
- QCSLE
- QKALE
- QCSL114

BEAST

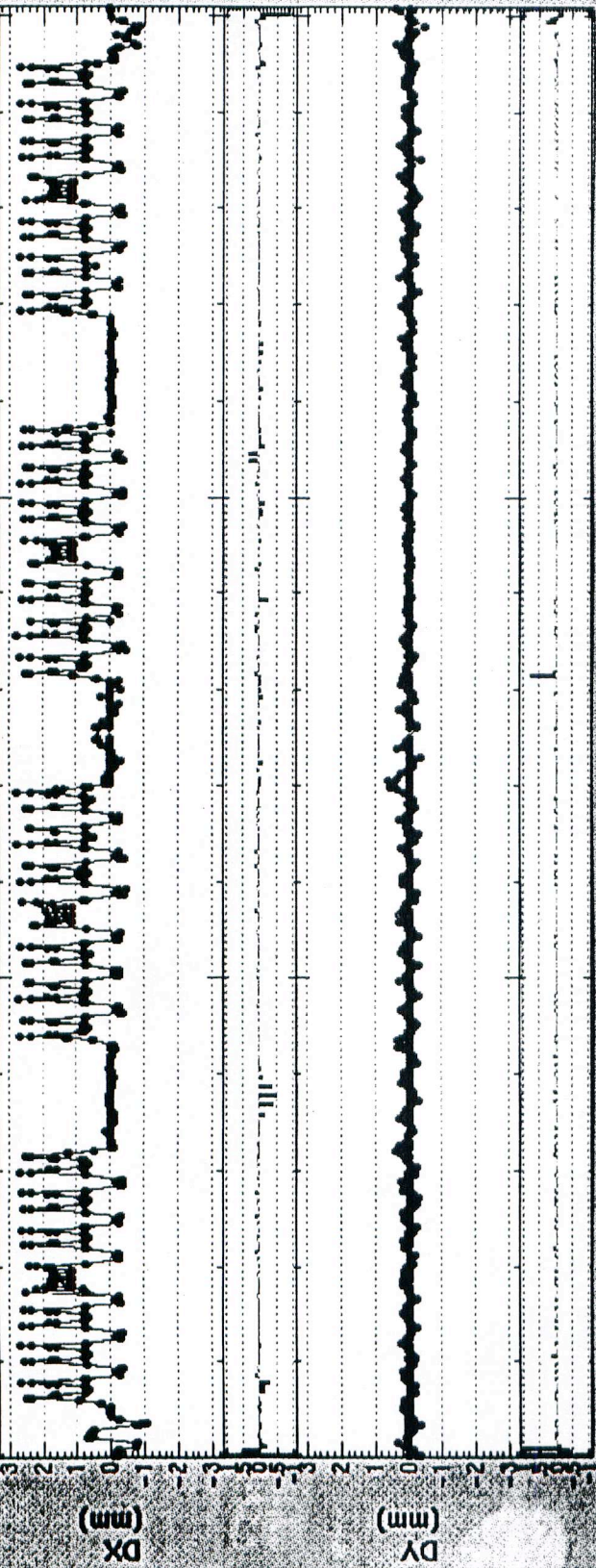
HER LER

Save Optics

LER Orbit Correction

DIFF_02_24_1999_21:08:21

*** mA



r.m.s = 1.235 mm
 max = 2.774 mm
 @ M193QF4P
 min. = -1.04 mm
 @ M010GB2LP
 2.613 mm
 @ M045QF4P
 (1.035 ± 1.346 mm)

r.m.s = .15 mm
 max = .601 mm
 @ M215QR5P
 min. = -.439 mm
 @ M450GC5RP
 301 mm
 @ M171QT5NFP
 (1.46 ± 347 mm)

- QC5L114
- QC3LP
- QC2LP
- QC5LP
- QD5P2
- QD3P2
- QD3P3
- QD5P5
- QD1P3
- QD5P1
- QD5P1
- QD5P2
- QD5P3
- QD5P4
- QD5P5
- QD5P6
- QD5P7
- QD5P8
- QD5P9
- QD5P10
- QD5P11
- QD5P12
- QD5P13
- QD5P14
- QD5P15
- QD5P16
- QD5P17
- QD5P18
- QD5P19
- QD5P20
- QD5P21
- QD5P22
- QD5P23
- QD5P24
- QD5P25
- QD5P26
- QD5P27
- QD5P28
- QD5P29
- QD5P30
- QD5P31
- QD5P32
- QD5P33
- QD5P34
- QD5P35
- QD5P36
- QD5P37
- QD5P38
- QD5P39
- QD5P40
- QD5P41
- QD5P42
- QD5P43
- QD5P44
- QD5P45
- QD5P46
- QD5P47
- QD5P48
- QD5P49
- QD5P50
- QD5P51
- QD5P52
- QD5P53
- QD5P54
- QD5P55
- QD5P56
- QD5P57
- QD5P58
- QD5P59
- QD5P60
- QD5P61
- QD5P62
- QD5P63
- QD5P64
- QD5P65
- QD5P66
- QD5P67
- QD5P68
- QD5P69
- QD5P70
- QD5P71
- QD5P72
- QD5P73
- QD5P74
- QD5P75
- QD5P76
- QD5P77
- QD5P78
- QD5P79
- QD5P80
- QD5P81
- QD5P82
- QD5P83
- QD5P84
- QD5P85
- QD5P86
- QD5P87
- QD5P88
- QD5P89
- QD5P90
- QD5P91
- QD5P92
- QD5P93
- QD5P94
- QD5P95
- QD5P96
- QD5P97
- QD5P98
- QD5P99
- QD5P100

range DX Auto Fix (3) DY Auto Fix (3) Replot

meas J stat J ref J meas-ref J stat-ref J calc

meas->ref stat->ref Save meas Save ref Save meas-ref Clear Statistics Standard Size

$$\frac{\Delta f_{RF}}{\Delta P} (-200 \text{ Hz}) - (0 \text{ Hz})$$

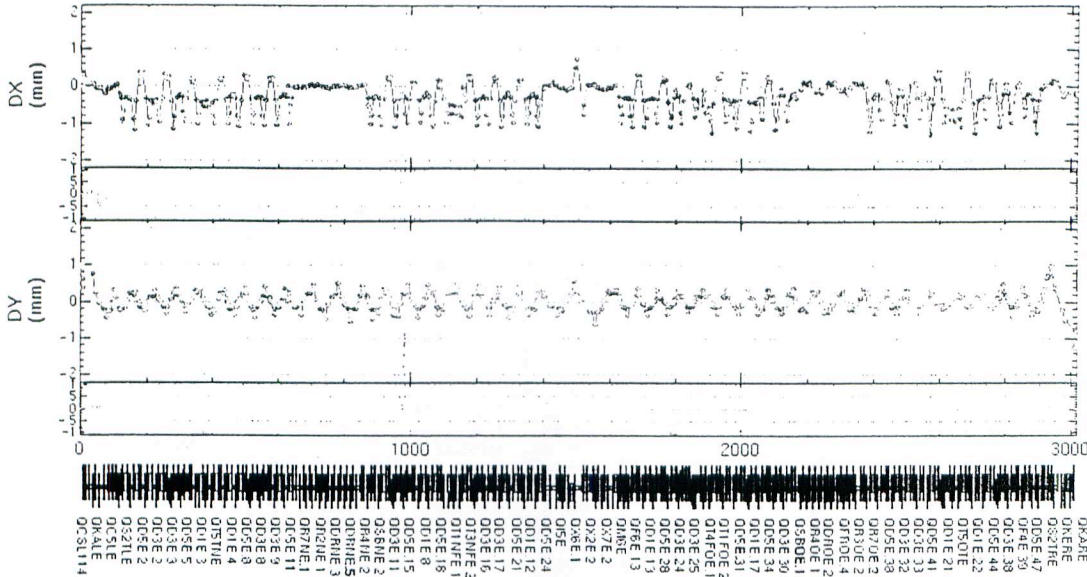
$$\frac{\Delta P}{P} + 0.23\% - 0\%$$

$$\frac{\text{meas}}{\text{model}} = 1.16$$

KEKB HER Orbit

77.446 mA

measured 02/23/1999 14:50:05



r.m.s = 1.665 mm
 max. = 3.504 mm
 @ M005OC3LE
 min. = -5.145 mm
 @ M378OF4E

r.m.s = 1.28 mm
 max. = 4.839 mm
 @ M439OC4RE
 min. = -3.191 mm
 @ M295GD3E

+200 - 100

~~100~~

range DX Auto Fix (2) ▲ ▼ DY Auto Fix (2) ▲ ▼ Replot

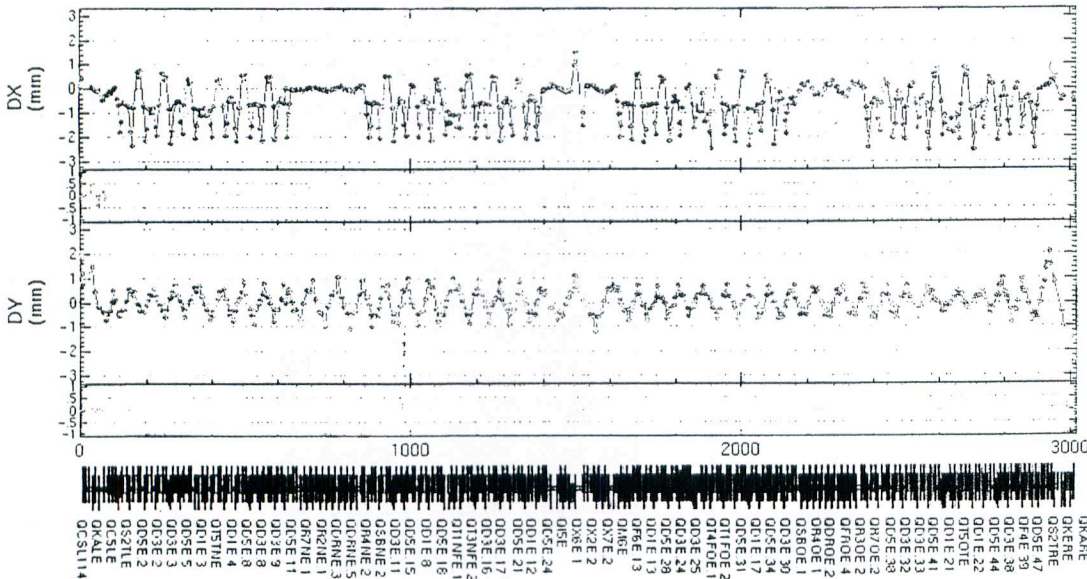
Ring -T- T-N -N- N-F -F- F-O -O- O-T @ BPMx @ BPMy
 meas stat ref meas-ref stat-ref calc meas->ref stat->ref Save meas Save ref Save meas-ref Clear Statistics Standard Size

Hard Copy

KEKB HER Orbit

75.967 mA

measured 02/23/1999 14:53:50



r.m.s = 2.11 mm
 max. = 3.544 mm
 @ M005OC3LE
 min. = -6.396 mm
 @ M378OF4E

r.m.s = 1.468 mm
 max. = 4.663 mm
 @ M439OC4RE
 min. = -3.518 mm
 @ M295GD3E

+300 - 200

range DX Auto Fix (3) ▲ ▼ DY Auto Fix (3) ▲ ▼ Replot

Ring -T- T-N -N- N-F -F- F-O -O- O-T @ BPMx @ BPMy
 meas stat ref meas-ref stat-ref calc meas->ref stat->ref Save meas Save ref Save meas-ref Clear Statistics Standard Size

Status Display

↑ HER dispersion

DIFF-02-23-1999-14:55:10

KEKB Ring Optics

Name: 24 B99C

Convergency .07760

$\gamma_x = 45.59018$ $\gamma_y = 44.26027$
 $\beta_x = 1.01252$ m $\beta_y = .01974$ m

Ring

Tune Adjust

IR

Normal Cells

Wiggler

Chromaticity

Magnet

- ξ_x .00000
- ξ_y .00000
- $\Delta p/p$.02000
- $\Delta p/p$ for ξ -trim .01000
- Δv_x (meas-model) -.04000
- Δv_y (meas-model) -.10000

Match

Back

History

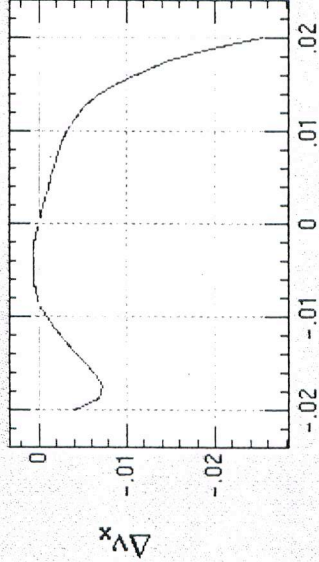
Convergence = .07760

- x range min max
- y range min max
- z range min max
- step

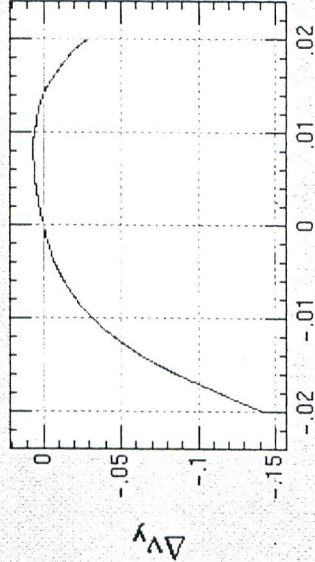
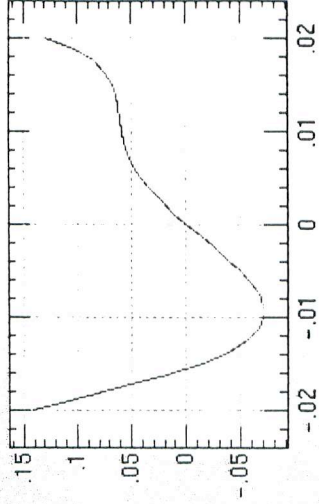
No. turns Show Result

Dynamic Aperture Survey

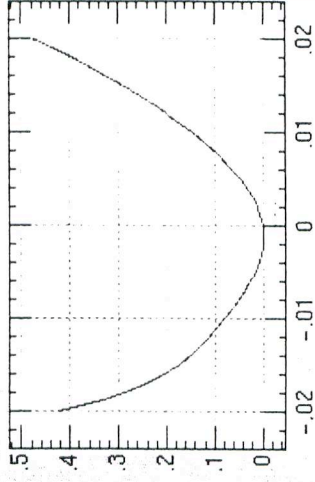
Display Chromaticity



$\Delta v_x/\beta_x$



$\Delta v_y/\beta_y$



Save Optics

HER

LER

BEAST

KEKB Ring Optics

Name: Temp02_24_1999_08:13:26

Convergence = .02801

$V_x = 44.62583$ $V_y = 42.19192$
 $\beta_x = .99786$ $\beta_y = .01999$

Ring

Tune Adjust

IR

Normal Cells

RF

Chromaticity

Magnet

- ξ_x .00000
- ξ_y .00000
- $\Delta p/p$.01700
- $\Delta p/p$ for ξ -trim .01000
- Δv_x (meas-model) .11900
- Δv_y (meas-model) -.07300

Match

Back History

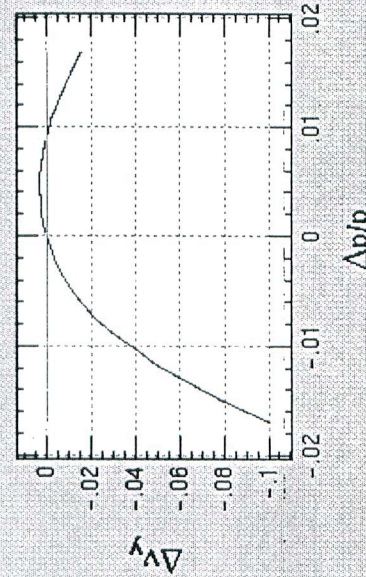
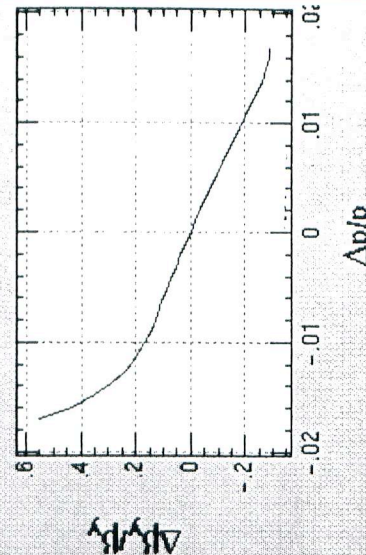
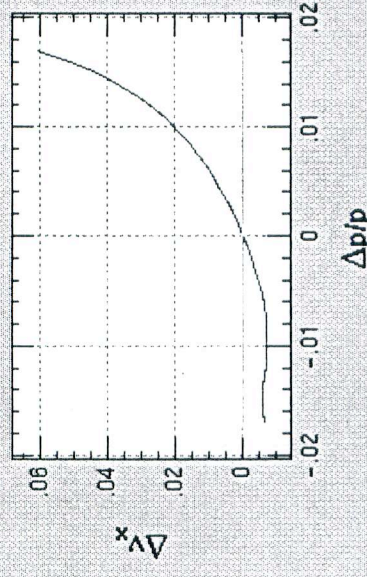
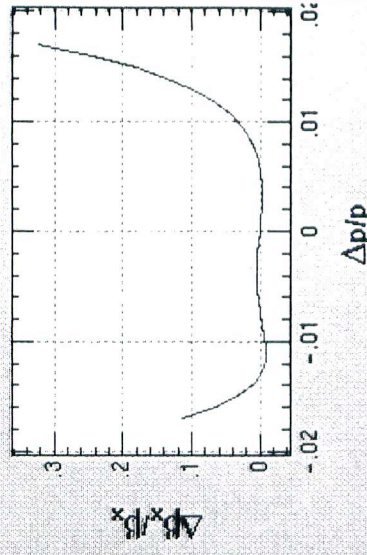
Convergence = .02801

- x range min 0 max 50
- y range min 0 max 16.7
- z range min -30 max 30
- step 1

No. turns 1 Show Result

Dynamic Aperture Survey

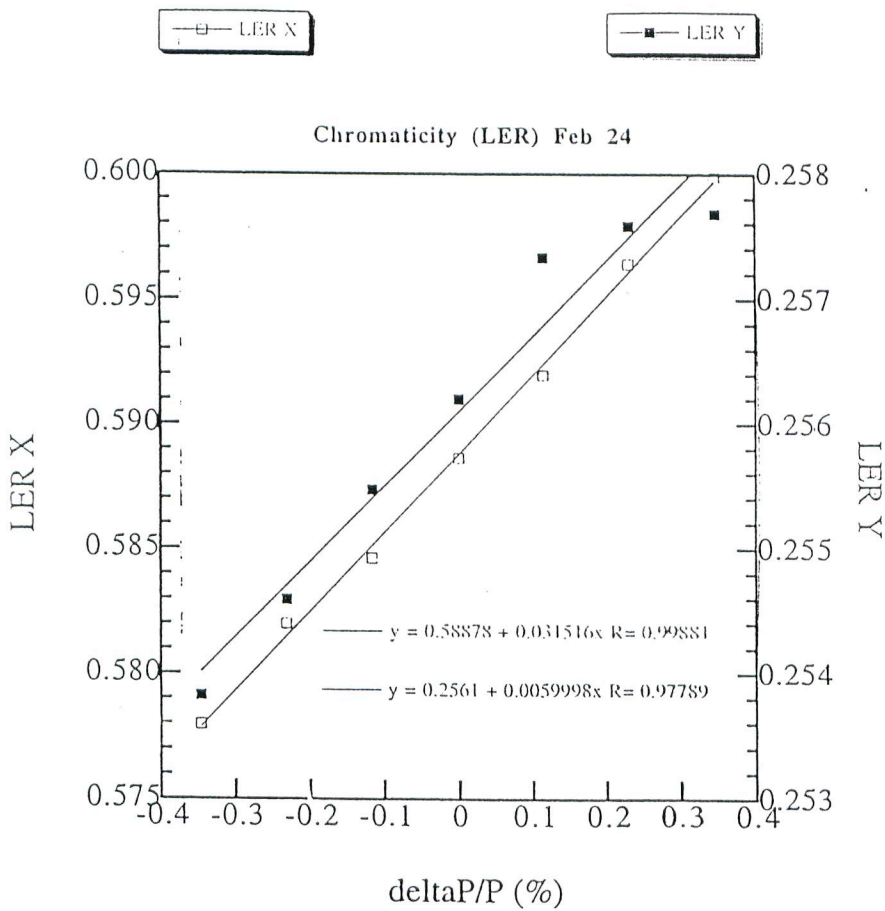
Display Chromaticity



Save Optics

HER LER

BEAST



LER

measured

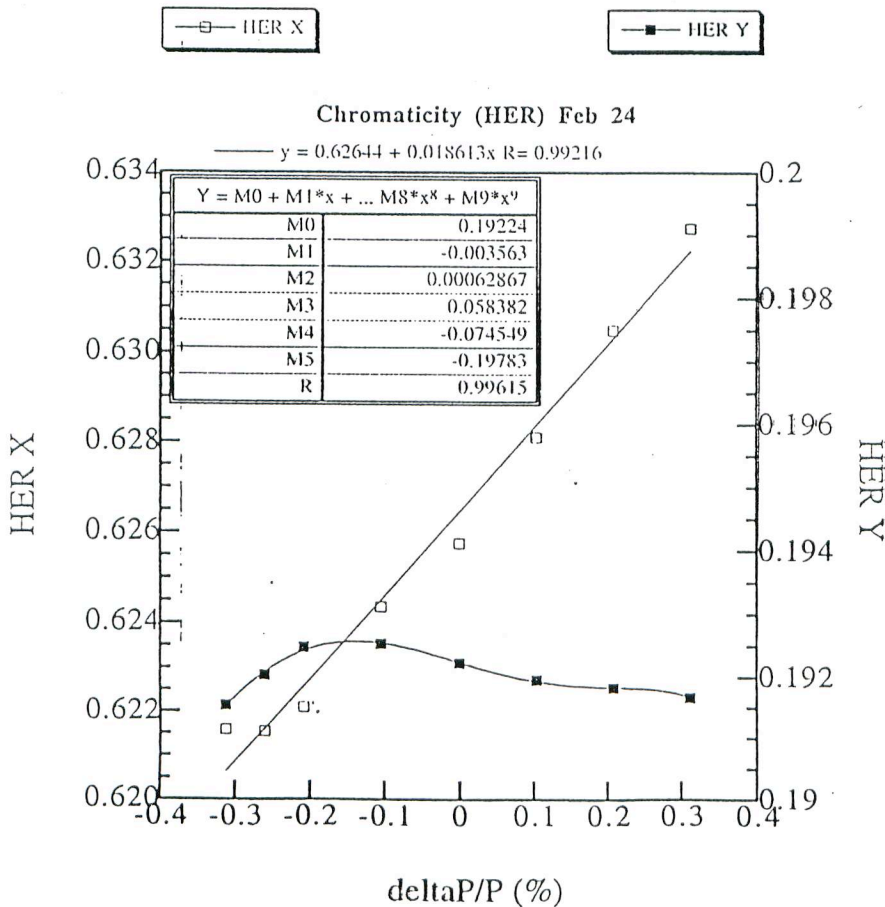
$$\sum x = 3.15$$

$$\sum y = 0.6$$

model

$$\sum x = -0.2$$

$$\sum y = +1.0$$



HER

measured

$$\sum x = 1.86$$

$$\sum y = -0.28$$

model

$$\sum x = +1.4$$

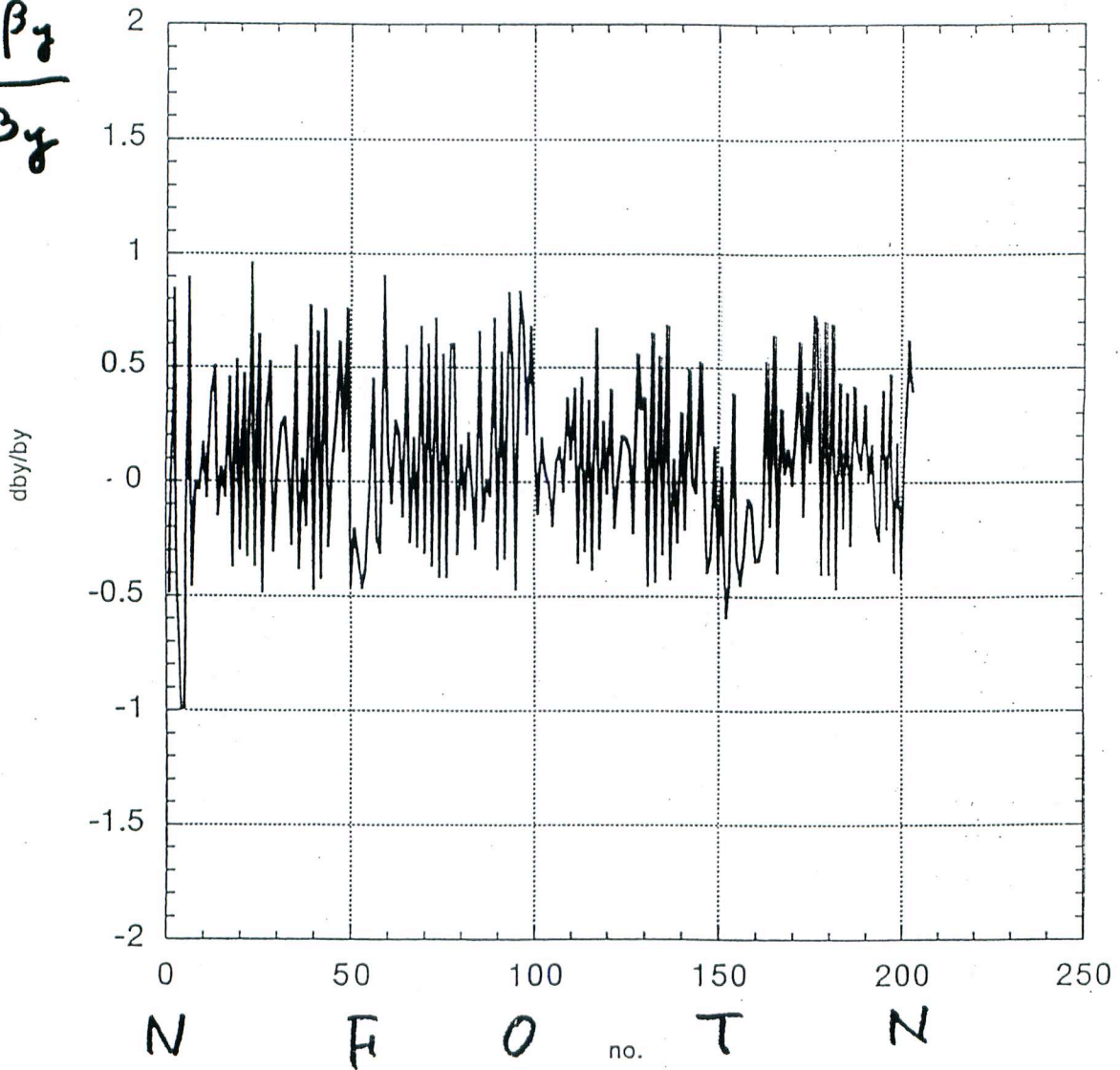
$$\sum y = +1.3$$

Chromaticity

— dby/by

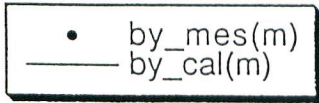
beta_mes_new_K

$$\frac{\Delta \beta_z}{\beta_y}$$



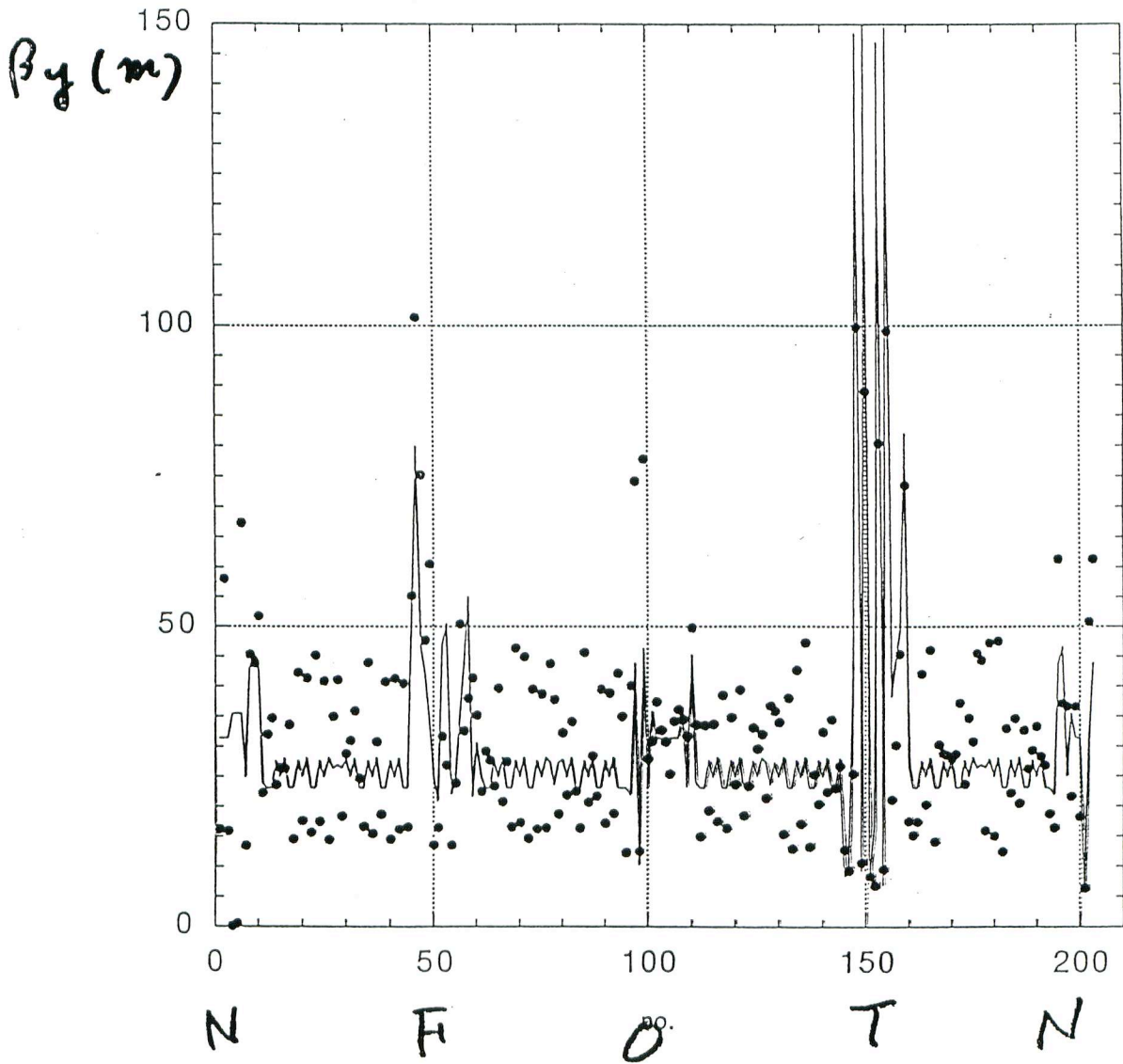
$$\frac{\Delta \beta}{\beta} = \frac{l}{2 \sin 2\pi V} \int k \beta \cos(2\pi V + 2\Delta\phi) dS$$

by H Fukuma

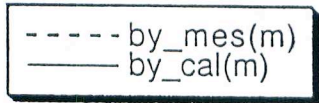


LER QD

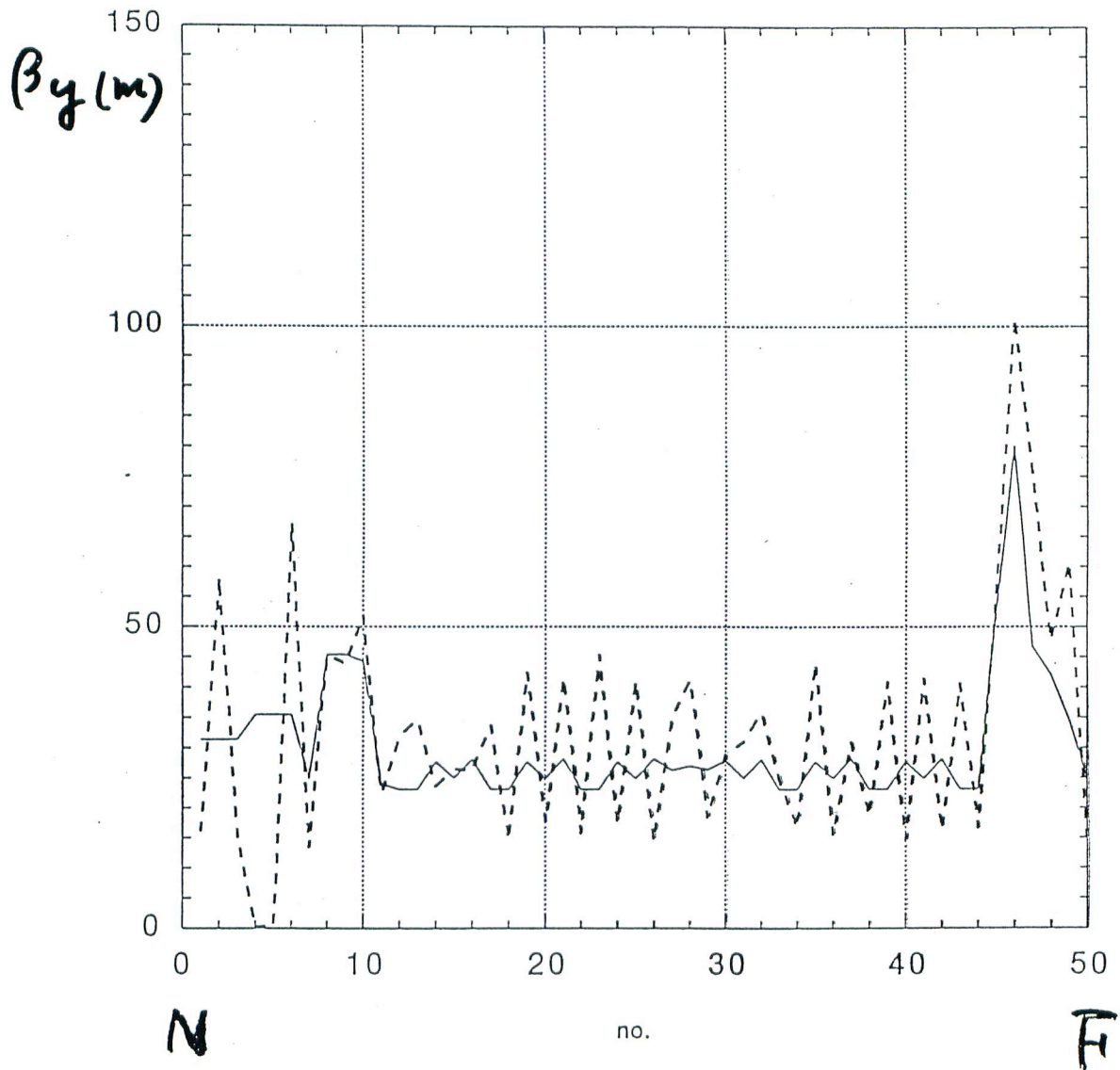
beta_mes_new_K



by H Fukuma



beta_mes_new_K

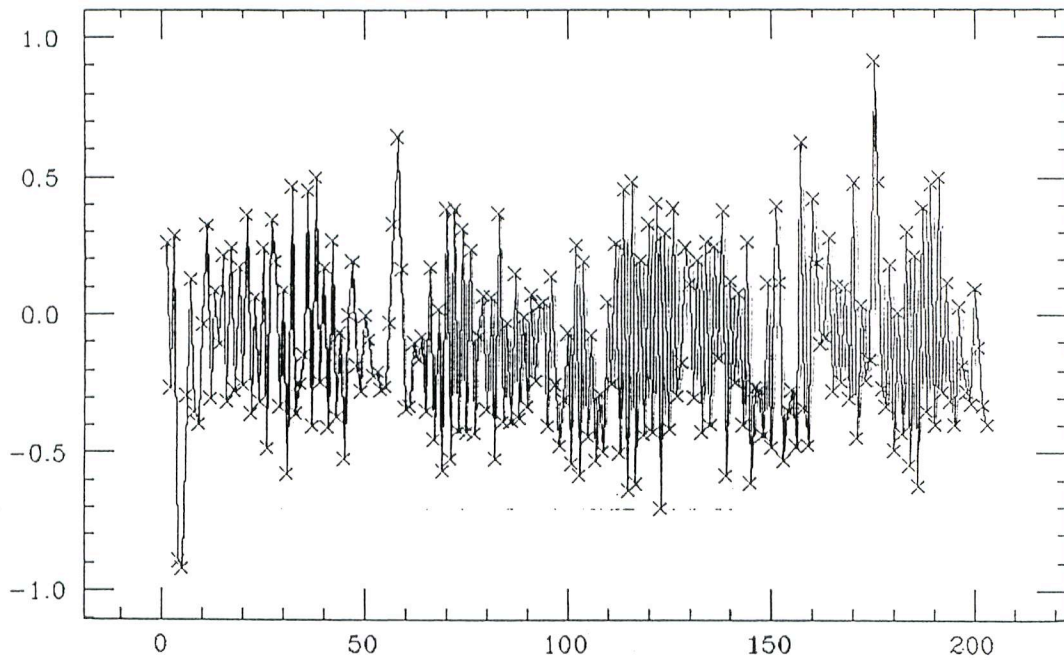


by H Fulcuma

measured

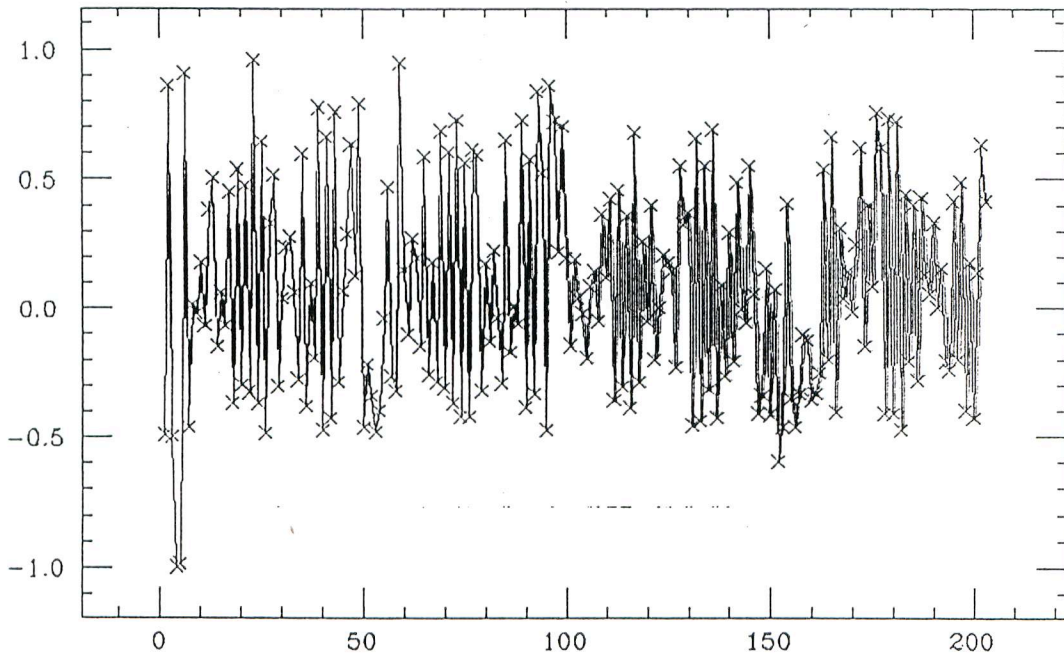
x data

$$\frac{\Delta\beta_x}{\beta_x}$$



y data

$$\frac{\Delta\beta_y}{\beta_y}$$

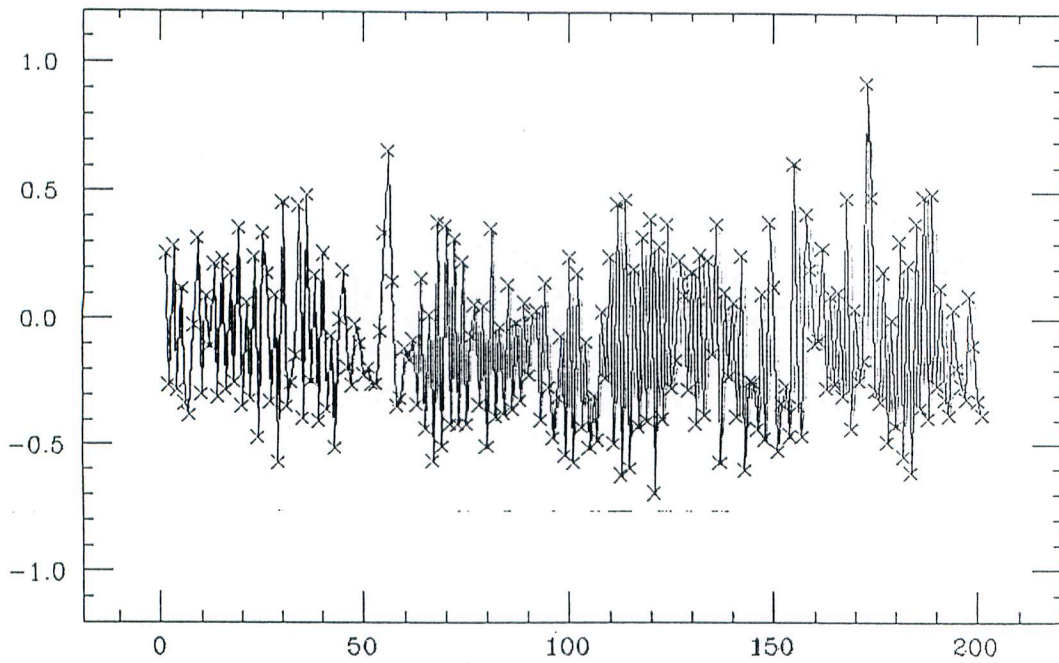


yの対称正

β_x $n=1$ QCSR 0.0066

expected after correction

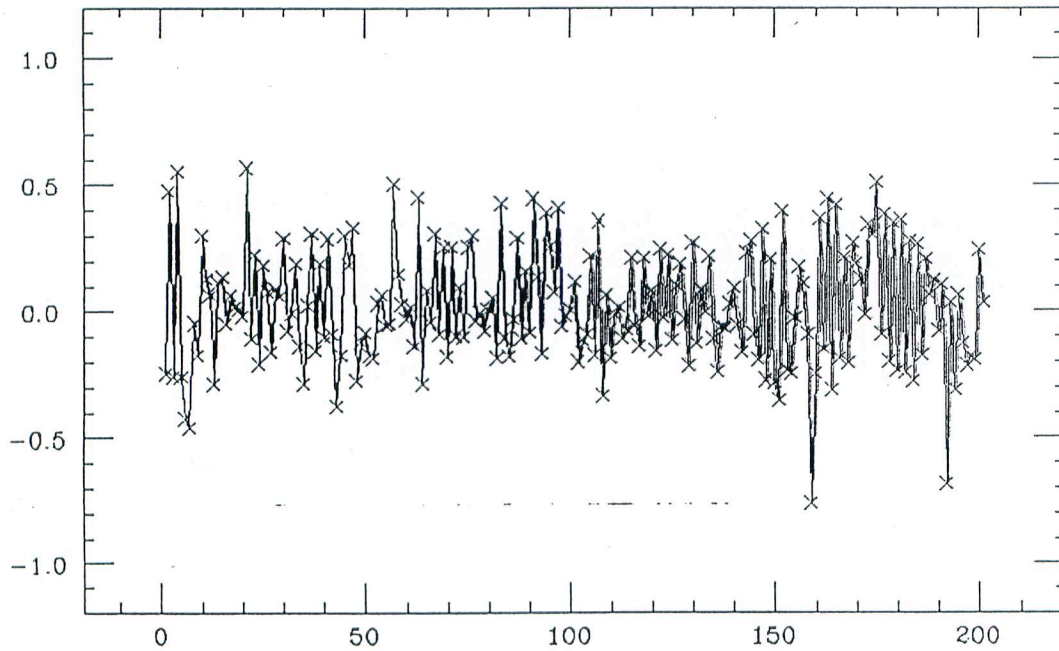
$$\frac{\Delta\beta_x}{\beta_x}$$



yの対称正

β_y $n=1$ QCSR 0.0066

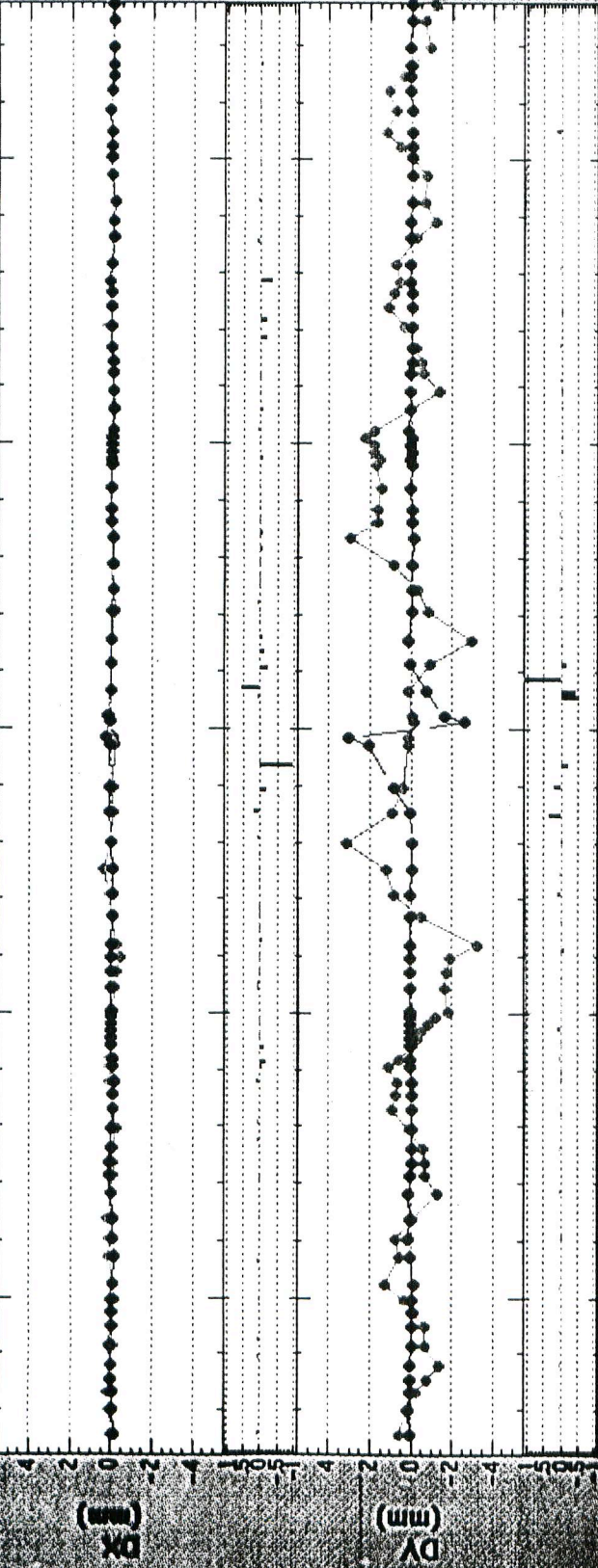
$$\frac{\Delta\beta_y}{\beta_y}$$



by M. Kikuchi

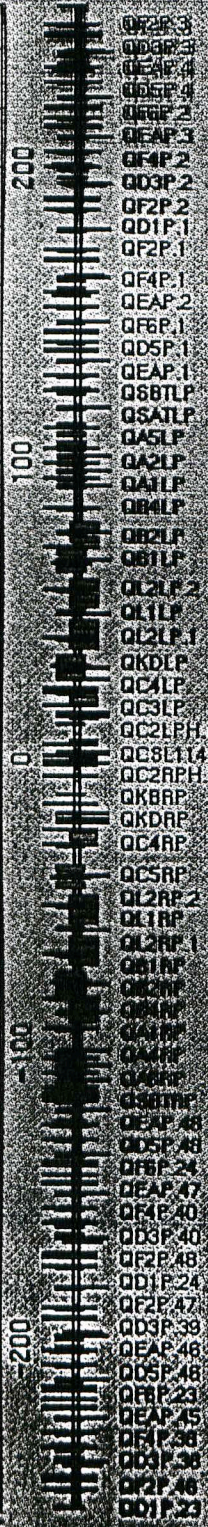
LER Orbit Correction

DIFF_02_18_1999_03:33:46



r.m.s = 07 mm
 max = 307 mm
 @ M454QCSR
 min = -202 mm
 @ M239QI6P
 115 mm
 @ M045QF4P
 (64 ± 1.093mm)

r.m.s = 238 mm
 max = 3.028 mm
 @ M454QCSR
 min = -2.618 mm
 @ M001QCSLP
 114 mm
 @ M171Q5NFP
 (.09 ± 24.3mm)



- QF4P.1
- QF4P.2
- QF2P.1
- QF2P.2
- QD1P.1
- QD1P.2
- QD3P.1
- QD3P.2
- QD5P.1
- QD5P.2
- QEAP.1
- QEAP.2
- QF6P.1
- QF6P.2
- QF8P.1
- QF8P.2
- QF10P.1
- QF10P.2
- QF12P.1
- QF12P.2
- QF14P.1
- QF14P.2
- QF16P.1
- QF16P.2
- QF18P.1
- QF18P.2
- QF20P.1
- QF20P.2
- QF22P.1
- QF22P.2
- QF24P.1
- QF24P.2
- QF26P.1
- QF26P.2
- QF28P.1
- QF28P.2
- QF30P.1
- QF30P.2
- QF32P.1
- QF32P.2
- QF34P.1
- QF34P.2
- QF36P.1
- QF36P.2
- QF38P.1
- QF38P.2
- QF40P.1
- QF40P.2
- QF42P.1
- QF42P.2
- QF44P.1
- QF44P.2
- QF46P.1
- QF46P.2
- QF48P.1
- QF48P.2
- QF50P.1
- QF50P.2
- QF52P.1
- QF52P.2
- QF54P.1
- QF54P.2
- QF56P.1
- QF56P.2
- QF58P.1
- QF58P.2
- QF60P.1
- QF60P.2
- QF62P.1
- QF62P.2
- QF64P.1
- QF64P.2
- QF66P.1
- QF66P.2
- QF68P.1
- QF68P.2
- QF70P.1
- QF70P.2
- QF72P.1
- QF72P.2
- QF74P.1
- QF74P.2
- QF76P.1
- QF76P.2
- QF78P.1
- QF78P.2
- QF80P.1
- QF80P.2
- QF82P.1
- QF82P.2
- QF84P.1
- QF84P.2
- QF86P.1
- QF86P.2
- QF88P.1
- QF88P.2
- QF90P.1
- QF90P.2
- QF92P.1
- QF92P.2
- QF94P.1
- QF94P.2
- QF96P.1
- QF96P.2
- QF98P.1
- QF98P.2
- QF100P.1
- QF100P.2

range DX Auto Fx (5) DY Auto Fy (5) Replot

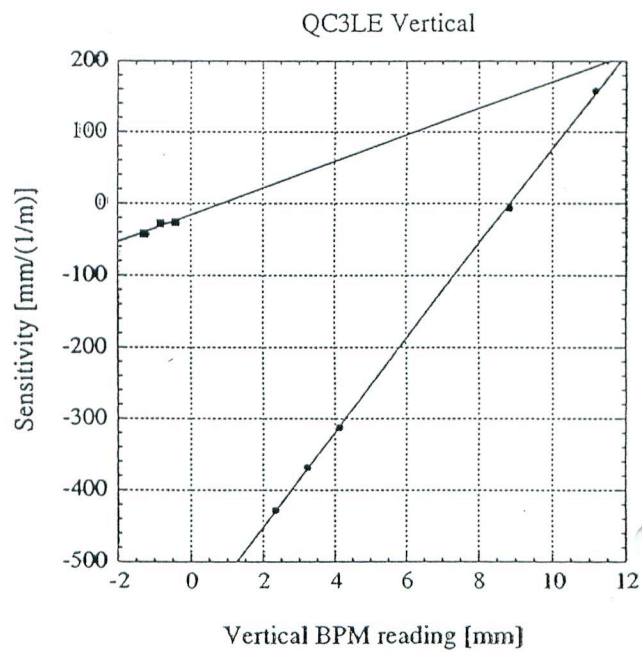
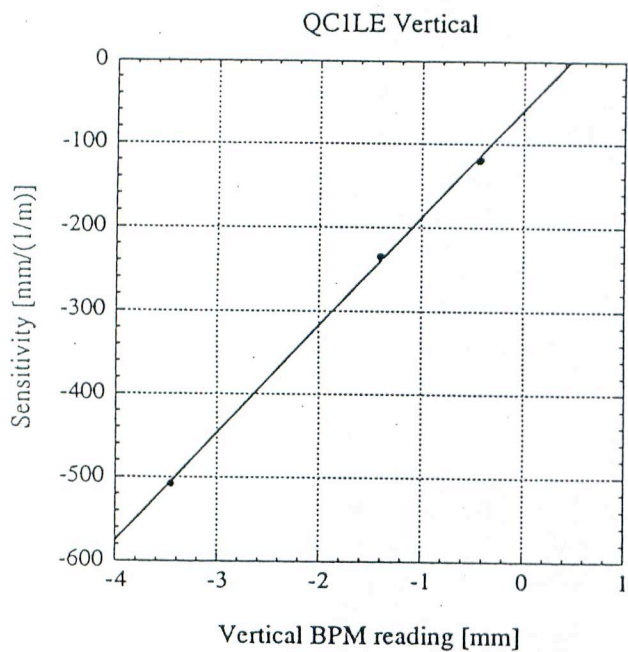
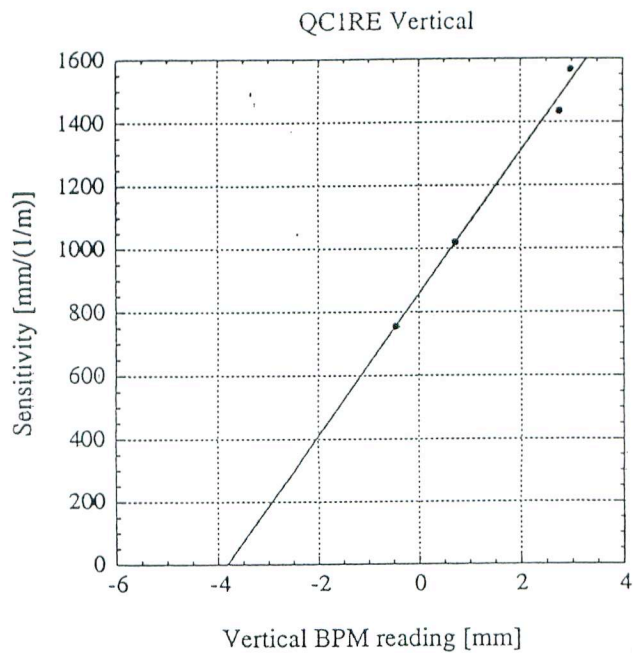
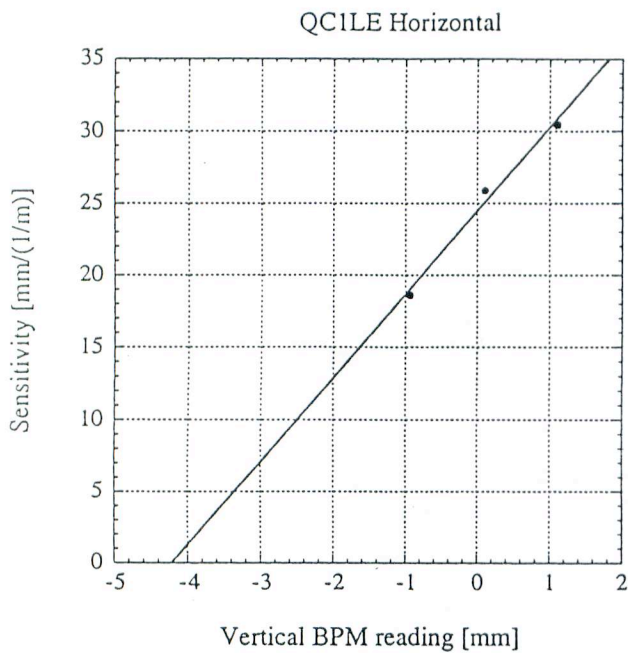
meas stat ref meas-ref stat-ref calc

meas -> ref stat -> ref meas -> ref stat -> ref

Save meas Save ref Save meas-ref

Graph Statistics Standard Size

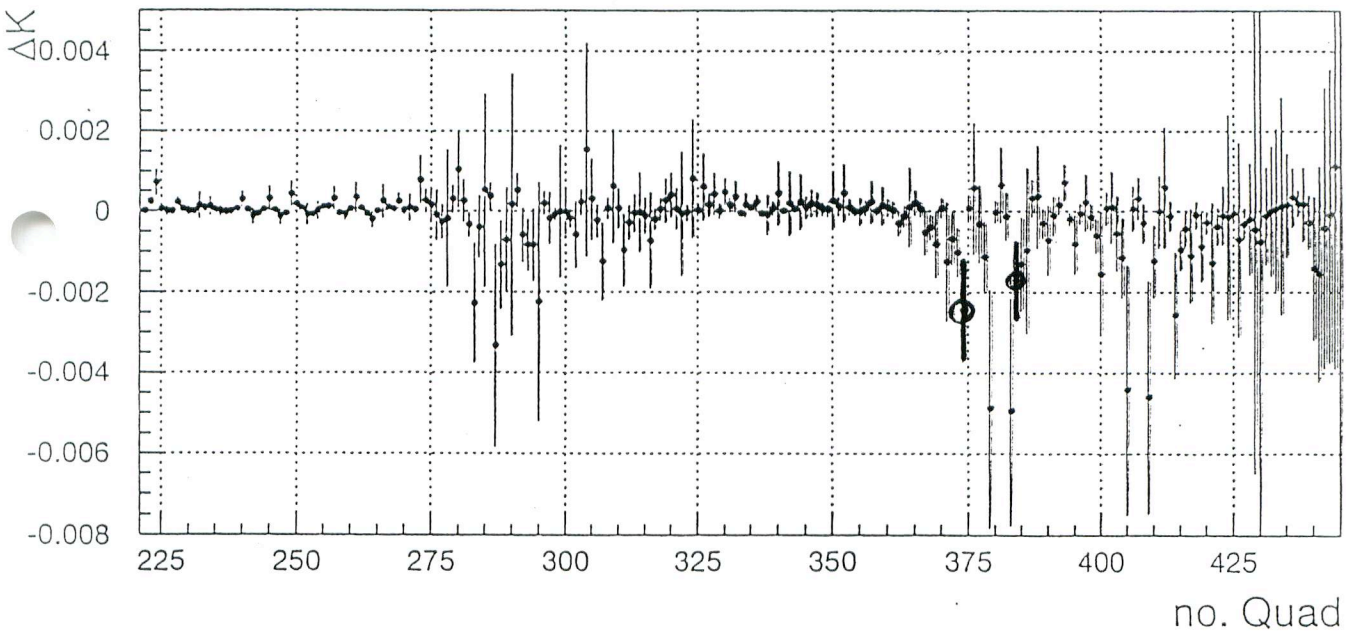
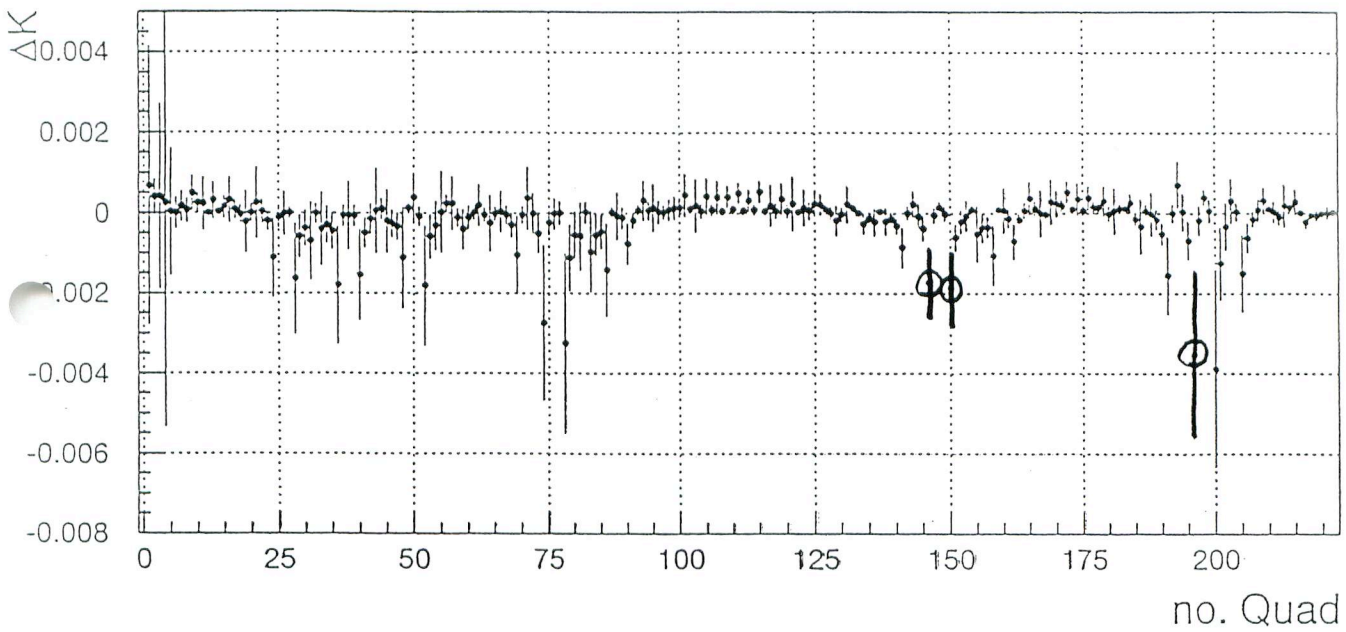
local bump at QCSR
 QCSL



Beam-based measurement of
BPM offset

by N. Akasaka
M. Masuzawa

HER Gradient Error of Quad from Vertical Kick Analysis



Single kick Analysis (HER)

by Y. Onishi

Model of LER Bend

3/4/1999 K. Oide

	Tune shift
Flat rectangular bend	
Maxwellian hard fringe	$\Delta v_y = 0.40$
Slope of B_y , $B_y = B_y(s)$	$\Delta v_y = -0.037$
Integrated quadrupole	$\Delta v_y = -0.056,$ $\Delta v_x = +0.057$
Sextupole, $\int B_y''(s)x(s)ds$	$\Delta v_y = -0.112,$ $\Delta v_x = +0.114$

HER

$$\Delta v_x (\text{meas-model}) = -0.135 \quad \text{~~0.13~~ } +0.12$$

$$\Delta v_y (\text{meas-model}) = -0.198 \quad \text{~~0.1~~ } -0.08$$

$$\frac{0.198}{44} \sim 0.4\% \sim \frac{3.5 - 3.485}{3.5}$$

Tune deviations from model

	LER	HER
adjust energy, QCS	-0.01 -0.30	+0.12 -0.08
LER dipole model I + fudge factor	+0.04 -0.10	
LER dipole model II	-0.14 -0.20	
change by unknown reason	-0.14 -0.23	